ACTA SOCIETATIS ZOOLOGICAE BOHEMICAE

ACTA SOCIETATIS ZOOLOGICAE BOHEMICAE[1)]

Acta Soc. Zool. Bohem. Vol. 60, No. 1 issued 1996 April 5

ISSN 0862–5247 47678

Published and distributed by the Czech Zoological Society. Orders should be sent to the Czech Zoological Society, Viničná 7, CZ–128 00 Praha 2, Czech Republic. Print by the Čihák tisk, Štěrboholská 21, CZ–102 00 Praha 10, Czech Republic.

Annual subscription (Volume 60, 1996, 4 issues)

Institutional subscription:	Europe:	USD 80.00
	Other countries:	USD 90.00
Private subscription:	Europe:	USD 40.00
	Other countries:	USD 50.00

This issue was supported by the Český literární fond (Czech Literary Foundation).

[1)] A direct continuation of:
(i) Vol. 1 (1927–1932): Zpráva o činnosti československé zoologické společnosti za léta 1927–1932
(ii) Vol. 2–53 (1933–1989): Věstník československé společnosti zoologické (*Věst. Čs. Společ. Zool.*)
(iii) Vol. 54–56 (1990–1992): Acta Societatis Zoologicae Bohemoslovacae (*Acta Soc. Zool. Bohemoslov.*)

This issue is dedicated to Professor Vladimír Hanák on occasion of his 65th birthday

Prof Dr Vladimír Hanák, a reputable Czech zoologist and university teacher, in the course of chiropterological research in a quarry in the Little Carpathians (Slovakia). Prof Hanák celebrates his 65th birthday on 31 March 1996.
Photo by Miloš Anděra.

Acta Soc. Zool. Bohem. **60**: 3–12, 1996
ISSN 0862–5247

Abundance fluctuation in *Apodemus* spp. and *Clethrionomys glareolus* (Mammalia: Rodentia): a seven year study in an isolated suburban wood

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Received January 2, 1996, Accepted February 29, 1996
Published April 5, 1996

Abstract. Synusy of small mammals was studied in an isolated wood on the periphery of Prague. During the years 1987–1993, 75 standard trap lines (11 600 trap nights) were laid and 2549 individuals of 9 species were captured. Variation in abundance was analysed in species which were both eudominant and euconstant, i. e., in *Clethrionomys glareolus, Apodemus flavicollis* and *A. sylvaticus*. Differences between seasons as well as between years significantly contributed to the variation of abundance. While number fluctuations in *C. glareolus* and *A. flavicollis* were fairly synchronous, *A. sylvaticus* exhibited low abundance during the first peak of the above species. Effective population numbers in both *C. glareolus* and *A. flavicollis* were estimated to about 300 individuals.

Synusy, population dynamics, effective population numbers, small mammals

INTRODUCTION

Number fluctuations in woodland mice and voles have attracted a significant research effort in the last decades (e. g., Bergstedt 1965, Hoffmeyer & Hansson 1974, Zejda 1976, Montgomery 1980, Bashenina 1981). In recent years most attention has been paid to population regulation and the underlying behavioural mechanisms. Density dependent population dynamics were demonstrated both in *Apodemus* species and *Clethrionomys glareolus* (Montgomery 1989 b, c, Pucek et al. 1993). While *A. sylvaticus* is characterised by a strong regulation of late summer – winter growth, the latter species shows weaker density dependence in both halves of the year (Mallorie & Flowerdew 1994). Predation (Pucek et al. l. c.) and female spacing (Bujalska 1973, Gliwicz & Rajska-Jurgiel 1983, Wilson et al. 1993) were recognised as important factors in this regulation. Apart from density-dependent regulation weather (in *C. glareolus*) and seed crop determine the pattern of number fluctuation (Jensen 1982, Pucek et al. l. c., Mallorie & Flowerdew l. c.).

The aim of this study was to examine rodent populations in an isolated suburban wood and to compare them with literary data. The study was prepared in the context of an extensive project dealing with small-mammal populations in urban and suburban habitats of Prague (cf. Frynta et al. 1994). The wood of „Satalická bažantnice a Vinořský park“ was selected as a model locality for multidisciplinary studies of sympatric *Apodemus* species (cf. Čiháková & Frynta 1995). The present study is concerned with characteristics of the small-mammal synusy and temporal variation of abundance in the dominant species.

MATERIALS AND METHODS

The investigations were conducted in the suburban wood of „Satalická bažantnice a Vinořský park" (51 hectares) situated in the vicinity of the village Satalice on the periphery of Prague (Central Bohemia). The locality is a completely isolated dense deciduous wood with a contiguous hedgerow system in surrounding corn fields. The most common plant species present are *Quercus robur, Acer platanoides, A. pseudoplatanus* and *Fraxinus excelsior* (trees), *Sambucus nigra, Grossularia uva-crispa* (shrubs), *Urtica dioica, Geum urbanum, Anthriscus sylvestris, Ballota nigra* (herbs). The elevation of the locality varies within the range 256–275 meters a. s. l., mean yearly temperature and rainfall are 8.4 °C and 528 mm, respectively.

The sampling was carried out in 23 trap sessions from December 1987 to May 1993 (see Appendix 1). We used standard trap lines, each consisting of 50 snap-traps (size 10×5 cm) spaced by 5 meters and exposed for 3 or 4 successive nights. Traps were baited with a standard bait: pieces of wick fried in fat and flour. In total 75 lines were exposed in 20 different sites. These sites can be classified into four main types of the habitat: (1) Interior of the deciduous wood with a dense shrub layer (sites 5, 9, 11, 14, 15, 17), (2) Wood margins with a dense herb and shrub cover (sites 1, 2, 6, 7, 8, 10, 12, 19, 13), (3) Windbreakers and other wood stripes surrounded by arable lands. The ecotones were covered with high herb layer and/or shrubs (sites 3, 4, 16). (4) Wood stripe along the stream with dense shrubs (sites 18, 20). For a detailed description of vegetation cover see Čihaková (1994).

During 11 600 trap-nights 2549 individuals of small mammals were captured. The date, number and location of a trap were recorded for each animal. All the material is deposited in the collections of the Department of Zoology, Charles University, Prague.

The expressions of abundance listed below (further referred by following abbreviations) were calculated:

(1) Actual catch size (Ñ).

(2) Relative abundance - number of individuals per 100 trap-nights. A1 – the results of the first night of trapping only, A3 – the first three nights were included.

(3) Estimated catch size (N) was computed from actual catch sizes in the first three days of trapping according to Janion et al. (1968) and Pelikán (1976). Individual probabilities of capture were replaced by communal values calculated for the overall material of the given species, i. e., 0.07, 0.20 and 0.25 in *A. flavicollis, A. sylvaticus* and *C. glareolus*, respectively.

(4) Number of individuals per hectare (ex./ha) – the estimated catch size divided by the area of the stripe from which the animals were presumably removed (Pelikán 1975). The length of the stripe is determined by the length of the line, while its width cannot be directly ascertained in the field and should be replaced by values of observed range lengths adopted from the literature. Arbitrary widths of stripes were given 30, 50 and 60 meters for *C. glareolus, A. sylvaticus* and *A. flavicollis* respectively (Pelikán 1975, Rödl 1974 a, b). It is to be emphasized here that the precision of density estimation is rather low due to the lack of direct information about the size of the area from which the animals of the given species were removed. Therefore, we used these values only for the rough estimation of the effective population numbers.

Frequency (F) was calculated as a percentage of lines in which the given species was captured (sensu Balogh 1958). Dominance (D) was expressed as a percentage of the species in the actual catch. *Rattus norvegicus* was not included in these calculations due to its low trappability by small traps used in our study.

Effective population number (N_e) was calculated according Kimura (1983) from the time series of actual population number using formula:

$N_e = i / (\Sigma 1/N_1 + 1/N_2 + \ldots 1/N_i)$

N = actual population number in a given time

i = number of density estimations

Our estimation was based on the sequence of 12 density estimations (means for spring – early summer and late summer – autumn period of each year). Actual population number was calculated as the number of individuals per hectare multiplied by the area of the studied wood (50.6 hectares). Two zero values in *A. flavicollis* were replaced by the minimal non zero actual population size found in this species. All the statistical treatments were performed using the programme Statgraphics version 5.0.

RESULTS

Basic characteristics of the synusy

In total 2549 specimens belonging to 9 species were captured: 1156 specimens of *Clethrionomys glareolus* (Schreber, 1780), 588 specimens of *Apodemus flavicollis* (Melchior, 1834), 548 specimens of *Apodemus sylvaticus* (Linnaeus, 1758), 128 specimens of *Sorex araneus* Linnaeus, 1758, 101 specimens of *Microtus arvalis* (Pallas, 1779), 23 specimens of *Crocidura suaveolens* (Pallas, 1821), 1 specimen of *Neomys fodiens* (Pennant, 1771), 1 specimen of *Mus musculus* Linnaeus, 1758, and 3 specimens of *Rattus norvegicus* (Berkenhout, 1769).

Tab. 1. Factors affecting variation of the relative abundance (A3) in eudominant species as revealed by ANOVA procedure

Factor	d. f.	*Clethrionomys glareolus*		*Apodemus flavicollis*		*Apodemus sylvaticus*	
		F	P	F	P	F	P
Season	3	3.24	0.0274	7.59	0.0002	11.85	<0.0001
Year	6	7.05	<0.0001	3.93	0.0021	3.90	0.0022

The values of dominance and frequency computed for the total material are given in Fig. 1. Three species, *C. glareolus, A. flavicollis* and *A. sylvaticus* were both eudominant and euconstant (terminology according to Balogh 1958). *Sorex araneus* was dominant and constant. *Microtus arvalis* was subdominant and accessory in the total material, but its representation was highly variable in time. This fact can be attributed to the population cycles of this species in the surrounding field habitats. Other species were only marginally represented and can be classified as subrecedent and accidentary in the studied synusy.

Relative abundance of the synusy in the first three days of trapping (A3) was 21.65 individuals per 100 trap-nights, the corresponding value computed separately for the first day of trapping (A1) being 24.22.

Variation of abundance in time

Prior to further analysis we had to exclude the possibility that differences between study sites considerably bias the results. Analyses of variance (performed separately for the spring and autumn data) confirmed that there are no significant effects of study site on relative abundance in any eudominant species. Therefore this factor was removed from the model.

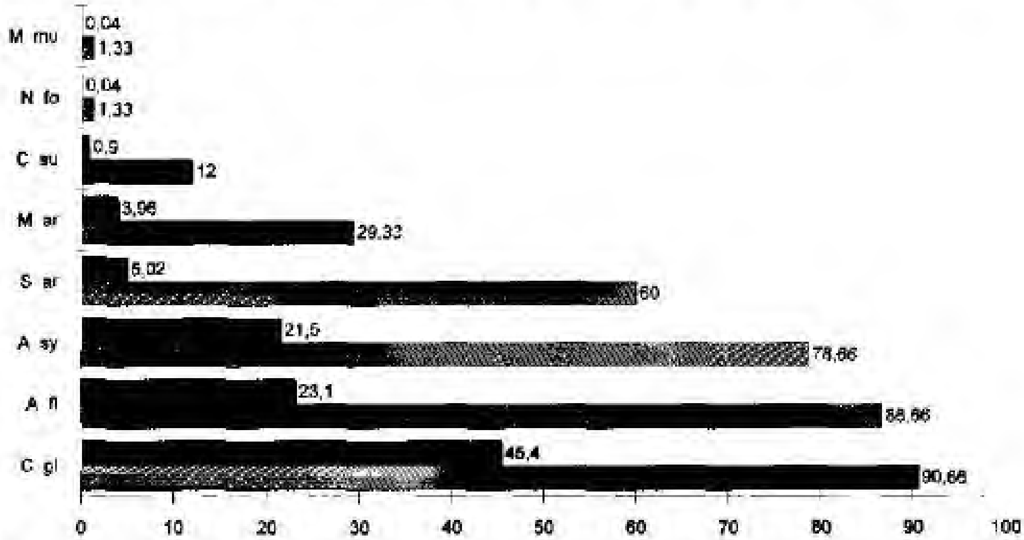

Fig. 1. Frequency (hatched bars) and dominancy (black bars) of individual species in the total material (M. mu.= *Mus musculus*, N. fo = *Neomys fodiens*, C. su = *Crocidura suaveolens*, M. ar. = *Microtus arvalis*, S. ar = *Sorex araneus*, A. sy = *Apodemus sylvaticus*, A. fl. = *Apodemus flavicollis*, C. gl. = *Clethrionomys glareolus*).

Tab. 2 Temporal fluctuation of mean relative abundance (A3) and density in the study area, A. sy. = *A. sylvaticus*, A. fl. = *A. flavicollis*, C. gl. = *C. glareolus*, A = autumn, S = spring

Period	n lines	Mean relative abundance (A3)			Mean number of ind. per hectare		
		A. sy.	A. fl	C. gl	A. sy	A. fl.	C. gl
A 1987	3	2.89	6.44	6.89	5.9	33.0	11.9
S 1988	12	1.06	3.78	17.33	2.2	19.3	30.0
A 1988	12	4.42	7.15	17.52	9.1	36.6	30.3
S 1989	2	2.33	1.67	1.00	4.8	8.5	1.7
A 1989	2	5.67	0.00	0.67	11.6	0.0	1.2
S 1990	2	6.00	1.00	1.67	12.3	5.1	2.9
A 1990	2	1.00	0.00	2.33	2.1	0.0	4.0
S 1991	8	1.00	0.92	2.42	2.1	4.7	4.2
A 1991	8	7.92	4.33	7.17	16.2	27.3	12.4
S 1992	8	1.67	3.08	6.42	3.4	15.8	11.1
A 1992	8	17.42	11.50	13.83	35.7	58.8	23.9
S 1993	8	2.17	7.00	10.25	4.4	35.8	17.7
Mean		4.46	3.99	7.29	9.1	20.4	12.6

Further on, we tested the effects of within and between year variation. Both season and year significantly contributed to the variation in relative abundance but the relative importance of these factors varied between species. Fluctuation between years was more pronounced in *C. glareolus*, while the seasonal changes predominated in both *Apodemus* species (Tab. 1).

(a) Within-year variation: Variation of the relative abundance during the year could be evaluated in the years of middle or high densities only. In all eudominant species it followed a common pattern characterized by spring decline and autumn peak (Fig. 2). The rapid increase of abundance usually occurred (with a single exception of *C. glareolus* in the year 1988) between the early and late summer samples. Therefore, for the description of the between-year fluctuation in relative abundance (A3) we pooled the data from the spring – early summer period as well as those from the late summer – autumn period (Tab. 2). Then the results for each period were plotted separately (Figs 3, 4). As expected, the between-year variation was higher in the late summer – autumn abundance.

(b) Between-year variation: In *C. glareolus*, high abundance in 1987 resulted in a population peak in 1988, followed by the period of low abundance in 1989–1990, growth in 1991, and finally the second peak in 1992–93. *A. flavicollis* displayed almost the same dynamics, however, there was no difference between the late summer – autumnal values in 1987 and 1988. Similarly, also *A. sylvaticus* exhibited high late summer – autumnal abundance in 1991 and especially in 1992. Other periods were characterised by low abundance with the exception of a small peak in 1989–90. Obviously the abundance of this species in 1987–1990 was not positively associated with those of *A. flavicollis* and *C. glareolus*.

(c) Effective population numbers: The absence of immigration is needed for the simple estimation of effective population number. Our locality is an isolated wood surrounded by open landscape and, therefore, unlike in *A. sylvaticus*, a very low immigration rate should be expected in *C. glareolus* and *A. flavicollis*, i. e., rodents strictly dependent upon woodland habitat. Estimated population numbers in these species were 300 and 335, respectively.

DISCUSSION

Although the abundance of the dominant species exhibited a great temporal dynamics, it apparently varied within the range reported from natural deciduous forests in Central Europe (Zejda 1973, 1976, Pelikán et al. 1974, Čiháková et al. 1993). However, there was a higher relative representation of *A. sylvaticus* in our samples. On the other hand, when compared with urban localities of Prague (Frynta et al. 1994), we found higher dominances of *A. flavicollis* and *C. glareolus*. Thus species composition of the synusy corresponds well with the intermediate – suburban nature of our locality. A similar representation of dominant species was described, e. g., in the false acacia stands near the city of Brno (Pelikán 1989).

Within-year variation of abundance followed the same pattern with spring decline and autumn peak as reported by most authors who studied woodland voles and mice (Ashby 1967, Montgomery 1979, 1989 a, c). We found that the within-year differences contributed more than the between-year ones to the overall variation of abundance in *Apodemus* species. It conforms with recent studies suggesting strong intrinsic regulation of wood-mice populations in the late summer – autumn period (Montgomery 1989b, Wilson et al. 1993, Mallorie & Flowedrew 1994). However, the variation between the years were also significant.

Pucek et al. (1993) suggest that population outbreaks of *A. flavicollis* regularly occur in the year following the oak heavy mast. Association of the abundance with seed supply was reported also in both *A. sylvaticus* (Akbar & Gorman 1993) and *C. glareolus* (Jensen 1982). Jensen (1985) showed that *Quercus*, *Fagus* and *Corylus* seeds are preferred as energy rich foods by

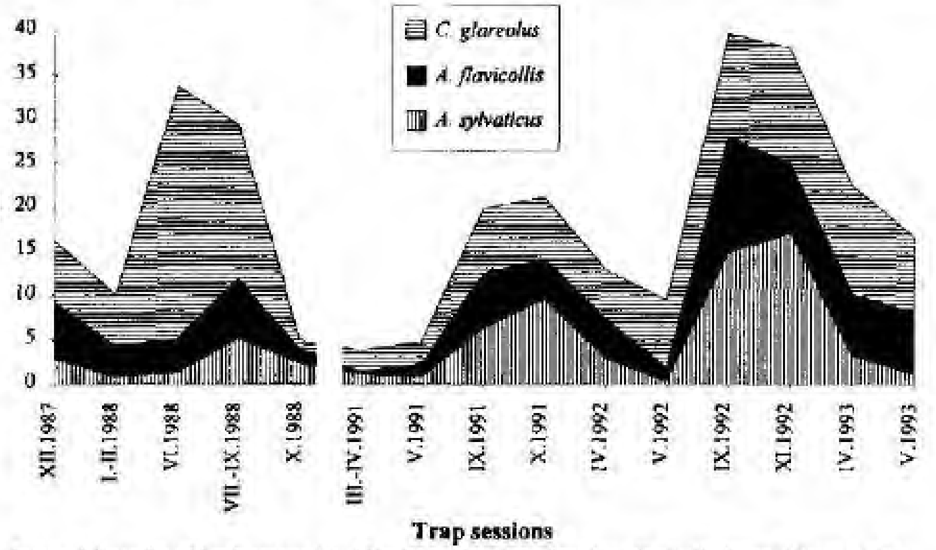

Fig. 2. Seasonal dynamics of dominant species. A3=relative abundance (number of individuals per 100 trap-nights).

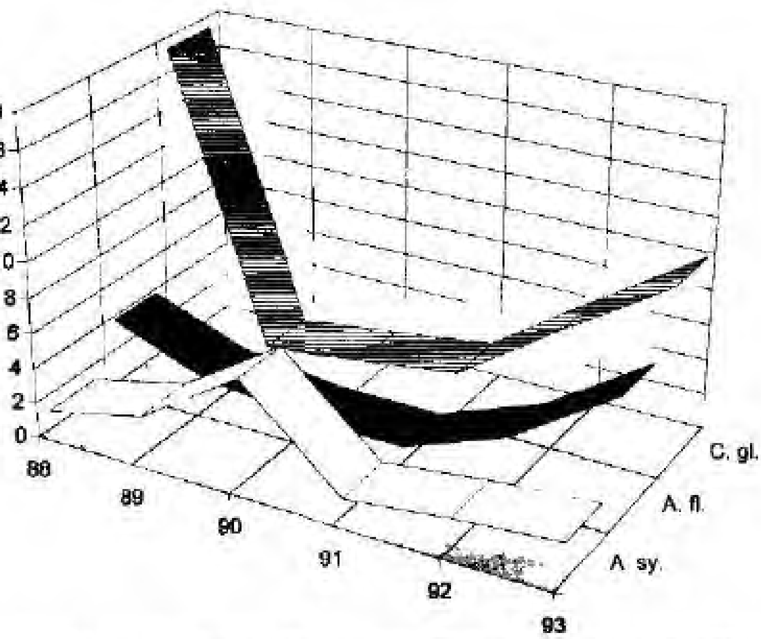

Fig. 3 Between-year variation in spring numbers. Abscissa: years, ordinate: number of individuals per 100 trap-nights (A3).

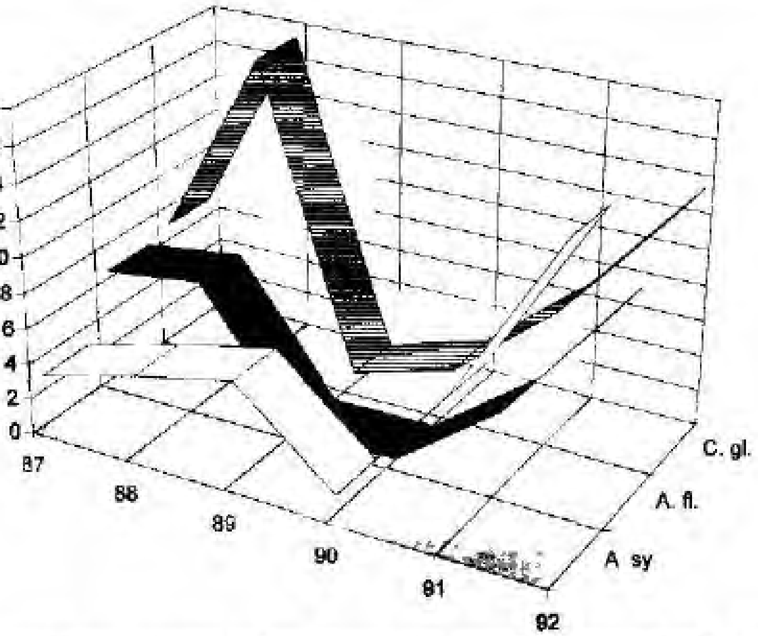

Fig 4. Between-year variation in autumnal numbers. Abscissa. years, ordinate: number of individuals per 100 trap-nights (A3)

C glareolus and *A flavicollis* In central Bohemia, heavy seed crops produced by oak and beech trees were recorded in 1986 and especially in 1992 (Novotný in verb) The former one corresponds well with the high abundance of *C glareolus* and *A flavicollis* in 1987 and 1988 The latter heavy seed crop occurred just in the time of synchronised peak abundance found in all studied species Therefore, being subsequent to the population growth, heavy seed crop cannot be the sufficient cause for this synchronous outbreak Evaluating the possible effects of heavy seed crops in oak trees, a great species diversity of trees producing seeds in our locality should be mentioned

Effective population numbers computed from our data were small enough to be the cause of rapid microevolutionary changes Moreover, in the case of *A flavicollis*, the effective population number was probably overestimated (cf replacement of zero values) On the other hand, even limited immigration could strongly devaluate our results Nevertheless, small effective population numbers remains to be a suitable explanation for the occurrence of changes in frequencies of non-metric characters in *Apodemus* species during our study (Čiháková & Frynta, unpubl)

Acknowledgements

We are grateful to Vladimir Hanák for his valuable suggestions and kind inclination to our research interests We also thank Jaroslav Čihak for the technical assistance in collecting materials in the field The research was supported by Charles University grant GUK 173/93

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APPENDIX I.

Survey of small mammals captured. For each line the total number of individuals captured during the three night session is given. *In the lines exposed for four nights the values are expressed as A+B, where A is number of individuals captured during* the first three nights and B is number of individuals captured during the additional fourth night

Session Date	Site No.	A. fl	A. sy	M. mu	C. gl	M. ar	S. ar	C. su	N. fo	Total
December	4	4	7	0	16	0	1	0	0	28
1987	19	7	6	0	15	0	0	0	0	28
	16	18	0	0	0	0	1	0	0	19
January	1	3	0	0	2	0	0	0	0	5
1988	14	1	0	0	2	0	0	0	0	3
	15	9	2	0	24	1	1	0	0	37
February	13	6+1	3	0	8+2	0	1	0	0	21
1988	8	7+1	2	0	4+3	0	0	0	0	17
	7	7+3	0	0	14+1	0	2	0	0	27
June	4	5	2	0	66	0	2	0	0	75
1988	19	7	3	0	44	0	4	0	0	58
	16	7	3	0	10	0	0	0	0	20
June	13	7	3	0	42	0	1	0	0	53
1988	8	4	1	0	41	0	2	0	0	48
	7	5	0	0	54	0	4	0	0	63
August –	2	10	5	0	45	2	7	0	0	69
September	3	13	20	0	30	3	2	0	0	68
1988	17	25	6	0	45	0	0	0	0	76
September	18	1	2	0	4	1	8	4	0	20
1988	20	4	5	0	7	1	2	1	0	20
	90	8	8	0	26	1	10	2	0	55
October	2	18	10	0	29	0	4	0	0	61
1988	3	17	0	0	27	0	1	0	0	45
	17	5	1	0	27	0	3	0	0	36
October	1	4	0	0	5	18	4	0	0	31
1988	12	3	14	0	12	7	0	0	0	36
	10	10	2	0	32	0	2	0	0	46
May	2	2	3	0	2	4	0	0	0	11
1989	3	3	4	0	1	3	1	0	0	12
November	2	0	3	0	0	17	3	0	0	23
1989	3	0	14	0	2	1	1	0	0	18
May	2	3	4	0	0	0	0	0	0	7
1990	3	0	14	0	5	0	1	0	0	20
November	2	0	3	0	0	0	0	0	0	3
1990	3	0	0	0	4	0	0	0	0	4
March	5	2	5	0	6	0	0	0	0	13
– April	6	0	0	0	0	0	0	0	0	5
1991	7	0	2	0	8	0	0	0	0	10
	8	0	0	0	0	0	0	0	0	0

Session	Site				species					
Date	No.	A fl	A sy	M mu	C gl	M ar	S ar	C su	N fo	Total
May	1	1	3	0	7	0	1	0	0	12
1991	2	3	1	0	0	0	0	0	0	4
	3	1	1	0	2	0	0	0	0	4
	4	4	0	0	6	0	0	0	0	10
September	9	9	15	0	24	0	2	0	0	50
1991	10	5	3	0	10	0	0	0	0	18
	11	15	14	0	4	0	0	0	0	33
	12	8	6	0	6	0	1	0	0	21
November	1	0	21	0	16	0	4	0	0	41
1991	2	7	6	0	3	0	3	0	0	19
	3	11	8	0	12	0	4	1	0	36
	4	9	22	0	11	0	2	0	0	44
April	5	14	12	0	5	0	0	0	0	31
1992	6	3	3	0	8	0	0	0	0	14
	7	6	3	0	11	2	0	0	0	22
	8	4	0	0	8	0	0	0	0	12
May	1	0	1	0	23	0	1	0	0	25
1992	2	2	0	0	1	0	0	0	0	3
	3	3	0	1	5	0	0	0	0	9
	4	5	1	0	16	0	0	0	0	22
September	9	12	31	0	22	4	2	1	1	73
1992	10	11+3	43+11	0	14+3	5+1	1	1+2	0	95
	11	28+3	5+1	0	23+1	0	1	0	0	62
	12	38+4	18+1	0	21+3	0	1+1	0	0	87
November	1	6+1	30+3	0	28+5	1	6+1	0	0	81
1992	2	14+5	21+1	0	8+3	12	3	0+6	0	73
	3	12+3	14+5	0	24+3	7	4	0+3	0	75
	4	17+7	47+14	0	26+6	2	7+1	0+2	0	129
April	5	12	5	0	24	0	3	0	0	44
1993	6	9	5	0	13	0	2	0	0	29
	7	8	7	0	20	1	6	0	0	42
	8	13	2	0	16	0	2	0	0	33
May	1	10	0	0	18	0	0	0	0	28
1993	2	21	0	0	8	2	0	0	0	31
	3	5	3	0	10	5	0	0	0	23
	4	6	4	0	14	0	1	0	0	25

Acta Soc. Zool. Bohem. 60: 13–23, 1996
ISSN 0862-5247

Species diversity and relative abundance of small mammals (Insectivora, Chiroptera, Rodentia) in the Pálava Biosphere Reserve of UNESCO

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Received November 22, 1995, accepted February 29, 1996
Published April 5, 1996

Abstract. From 1989 to 1993, small mammals were sampled in the territory of the Pálava Bioreserve (83 km²). The various methods of collecting included standard line and quadrat trapping, analyzing the pellets of owls, and netting and censusing of bats. In total, the material includes 6755 specimens or individuals of 38 species, of which are 6 Insectivora, 16 Chiroptera and 16 Rodentia. The sample obtained by standard line trapping consists of 11 species, its species diversity was 1.53 and total relative abundance 12.8 specimens per 100 trap-nights. According to the values of dominance, the communities of different biotopes are either mouse- or vole-type, no shrew-type community has been revealed. The absolute abundance estimated by quadrat trapping was 7.2 *Apodemus flavicollis* and 8.4 *A. sylvaticus* per hectare. The sample of owl pellets revealed 22 species, of which 5 rodent species were only recorded in pellets. Species diversity is high in the prey sample of *Bubo bubo* (2.57), medium in *Strix aluco* (2.10) and low in *Asio otus* (0.80). The sample of netted bats consists of 16 species, its diversity is 3.31 and total relative abundance 18.7 individuals per 100 meters of nets per night. The samples are dominated by *Myotis* and *Plecotus* species. Of other mammals, the first record of *Castor fiber* in the study area is most important.

Diversity, insectivores, bats, rodents, bioreserve, Czech Republic

INTRODUCTION

Monitoring of biodiversity has become one of the main tasks of present ecology (Barnes 1989, Reichholf 1993, Vernhes & Younes 1993, Barbault 1994). In a proposal for an international network, di Castri et al. (1992) recommended certain life forms and taxa to be selected for studying diversity of various ecosystem types and subtypes. Mammals have been included in the list of taxa to be studied in woodland ecosystems, and biosphere reserves have been considered suitable potential sites for intensive studies of this kind.

The Pavlovské vrchy Hills and their surroundings represent a small but very diverse region of S Moravia, situated on the border between the Czech Republic and Austria. Various types of woodlands cover most of this territory (Horák 1969). In 1976, it was proclaimed the protected landscape area under the name Pálava and in 1986, Pálava was proclaimed a Biosphere Reserve of the UNESCO.

The present study is a part of a project concerning the monitoring of abundance and diversity of non-aquatic vertebrates. Its goal is to assess the species richness and relative number of individuals of three mammalian taxocoenoses. Even this limitation posed certain problems con-

cerning the methodology of such research There is no universal method of sampling all guilds of insectivores, rodents and bats We tried to balance the selectivity of sampling by using as many diverse methods as possible On the other hand, we were eager not to prefer any guild to another by using more methods (or a more efficient method) to study it, compared to other guilds Therefore, we did not include the results of detecting bats via recording their ultrasound signals, since no equivalent method was available for rodents and insectivores The time span available for field work was limited to five years and approximately the same kind and amount of field work was performed each year

STUDY AREA

The Pálava Biosphere Reserve (83 km²) is situated in the Pannonian section of the Eurosiberian Steppes province Its climate is warm and moderately dry, with annual mean air temperatures of 9–10 °C and annual total precipitation of 450–570 mm Within the biosphere reserve there are six localities of special importance, having status of nature reverves or national nature reserves The core part of the Pálava is an Upper Jurassic limestone ridge about 12 km long and 3–4 km wide, with maximum elevation of 550 m (Mt Děvín) The southern and eastern slopes are rock steppes vegetated predominantly by pubescent oak forests, other slopes are vegetated mainly by oak-hornbeam and lime-maple forests Vineyards are planted on the foothills There is one larger cave (Na Turoldu cave) with more than 200 m of corridors and smaller domes, and three small caves up to 10 m long

The Milovice forest with sub-xerophilous oak and oak-hornbeam stands occupies most of the eastern part of the territory Some 25% of the woods have been clear-cut and transformed into clearings, small fields and meadows In 1965–1966 two game preserves were established (1250 and 500 ha, respectively) The game exert a great impact on the vegetation of that part of the reserve (Chytry & Danihelka 1993)

Well preserved, on the contrary, are the phytocoenoses of the Dyje River floodplain in the Křivé jezero Reserve, with a lowland forest and two more or less marshy meadows Natural floods occured there in the past and artificial flooding has been performed recently

Two fishponds (23 and 31 ha) are situated in the southern part of the territory, with reed beds on their banks and remnants of woods in their surroundings Agricultural land covers about 20% of the Pálava territory There are also nine villages and the town of Mikulov (7000 inhabitants) (Fig 1)

MATERIAL AND METHODS

In 1989 to 1993, invariably in May and October, small terrestrial mammals were trapped and we have labelled this method „standard line trapping" Each trapping campaign lasted three trap-nights and covered four localities Three lines of standard snap traps and one line of metal live traps of the Rodl type (Rodl 1975), baited with a piece of wick soaked in fat, were set in each locality There were 20 traps in each line spaced 5 m apart The sites of trap lines were altered during the research, resulting in a total of 14 localities including eight groups of biotopes a–h (Fig 1) The number of trap-nights per year was 1920 except in 1993 when it was smaller as a result of damage caused to some traps, so that the total number of trap-nights was 4771

Quadrat trapping was performed during each campaign of standard line trapping, always at the same site (Fig 1) There were 8×8 trapping points spaced 10 m in a quadrat grid with two baited snap traps at each point and the total of trap-nights was 3840 In additon a sample of small mammals collected by P Voříšek has been included in this study It was obtained in 1993 by snap trapping on lines of different trap numbers with a total of 1650 trap-nights Incidental finds and observations concerned 2 specimens of rodents

The pellets of three owl species were collected in 1989 to 1992 except for one sample of *Asio otus* which was collected in August 1988 The following were the numbers of localities and samples *Bubo bubo* 6 localities, 9 samples, *Strix aluco* 4, 8, *Asio otus* 3, 5 (Fig 1) The material was dissolved in 5% NaOH and from among mammalian skeletal remnants the jaws were considered decisive of both species identification and estimation of number of prey items Only mammals have been considered in this paper, for details concerning methods and the whole material, see Obuch (1992) The age of the pellets at the time of collecting was estimated at maximum two years in *S aluco* and *A otus* and 12 years in *B bubo*, according to the finds of pigeon rings in the pellets

The bat populations were sampled in 1989 to 1993 with an additional sample from January 1994 (hibernating individuals) The main sampling method was mist-netting at three localities (Fig 1) There were 47 netting campaigns with two to seven 5–12 m long nets per campaign Usually the nets were set one hour before sunset and lifted one hour after the next sunrise, in two cases (rain etc) the nets were exposed for half a night only The total number was 227 net-nights or 2024 net-

meter-nights, the latter value having been considered a better index to estimate the relative abundance of netted individuals. Another method of sampling bats was visual censusing of individuals hibernating in a cave. The census was carried out once a year in January.

Table 1 gives a survey of all samples evaluated in this paper. In all, the material includes 38 species and 6755 specimens or individuals.

RESULTS

Line trapping

Since most individual localities and all units comprise a mosaic of different biotopes, the material has been analyzed separately according to eight groups of biotopes (Tab. 2). The species diversity (Shannon–Weaver index) is highest in the sample of biotope d (shrubs on limestone soil), relative abundance in that of biotope g (floodplain meadows). Concerning the dominance

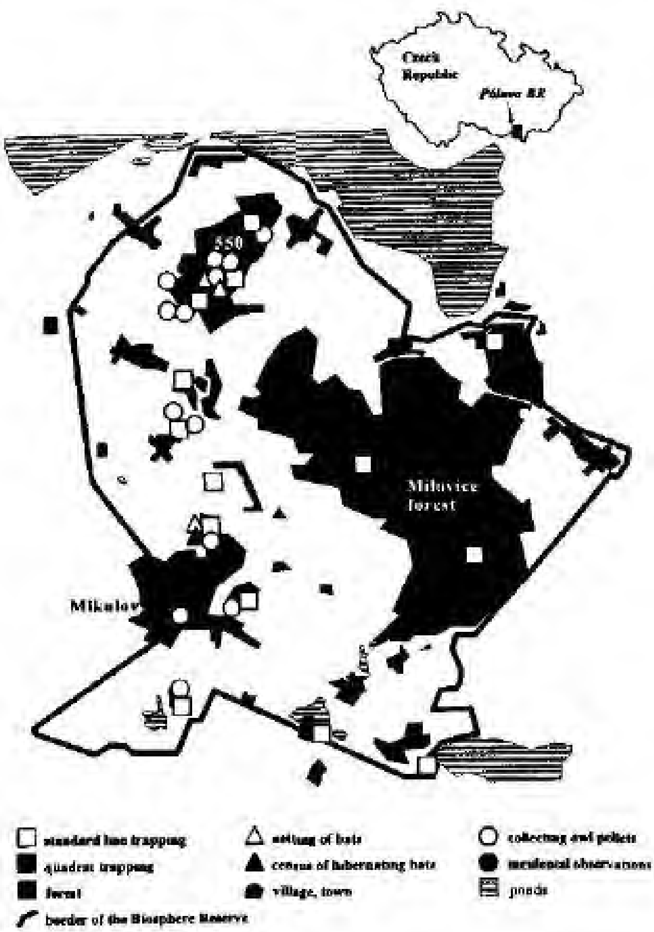

Fig. 1. Study area and its situation within the Czech Republic.

Tab. 1. General survey of the material collected. Explanations: capt. – captured, obs. – observed

Sample	No. of specimens				No. of species
	capt.	found	obs.	total	
Standard line trapping	1226	–	–	1226	11
Additional line trapping	206	–	–	206	7
Quadrat trapping	154	–	–	154	3
Owl pellets	–	4168	–	4168	22
Netting of bats	378	–	–	378	16
Census of hibernating bats	–	–	621	621	4
Incidental observations	–	2*	–	2	2
Total	1964	4170	6755	6755	38

* including one *Castor fiber* (signs of activity)

(Fig. 2), one superabundant species (50% and over) was found in four samples. It was *Microtus arvalis* in meadow biotopes a and g, and *Apodemus flavicollis* or *Clethrionomys glareolus* in forest biotopes b and f. Relatively well-balanced representation of species was found in the sample of biotope h (water edges) although it does not show the highest species diversity.

Live traps were used in order to increase the probability of catching shrews. Since there were three times more snap than live traps the number of snap trapped specimens was divided by three to compare the efficiency of the two trap types. Concerning all species coupled, live traps were more efficient. The difference is significant for the whole sample (χ^2=4.23, $p<0.05$) and for the October one (χ^2=5.50, $p<0.02$); it is insignificant for the May sample. However, live traps were not better to collect shrews, the difference between the numbers of specimens of Soricidae snap and life trapped being insignificant in all cases.

The sample of additional line trapping in the Milovice forest (Fig. 1) consists of 206 specimens of 7 species. It is interesting to note the presence of 5 *C. leucodon* trapped in the clearings and fields within the forest. This species has not been recorded during the standard line trapping campaigns.

Quadrat trapping

The quadrat plot situated in a lime-hornbeam forest, with both herb and shrub layers poorly developed, yielded 154 specimens of only three species: 92 *A. flavicollis*, 60 *A. sylvaticus* and 2 *C. glareolus*. The total relative abundance was 4.0 specimens per 100 trap-nights. The absolute abundance, estimated by the method of Pelikán (1971), was 7.2 *A. flavicollis* and 8.4 *A. sylvaticus* per hectare on average for the whole trapping period.

Analysis of owl pellets

Prey items of three owl species were identified from pellets collected at 13 localities. A total of 4168 specimens of 22 species was found (Tab. 3), not including 52 specimens of *Lepus europaeus* in the pellets of *B. bubo* (the order Lagomorpha is not the subject of the present paper). The species *Muscardinus avellanarius*, *Cricetus cricetus*, *Arvicola terrestris*, *Apodemus microps* and *Rattus norvegicus* were only recorded in owl pellets. With respect to the situation of collect-

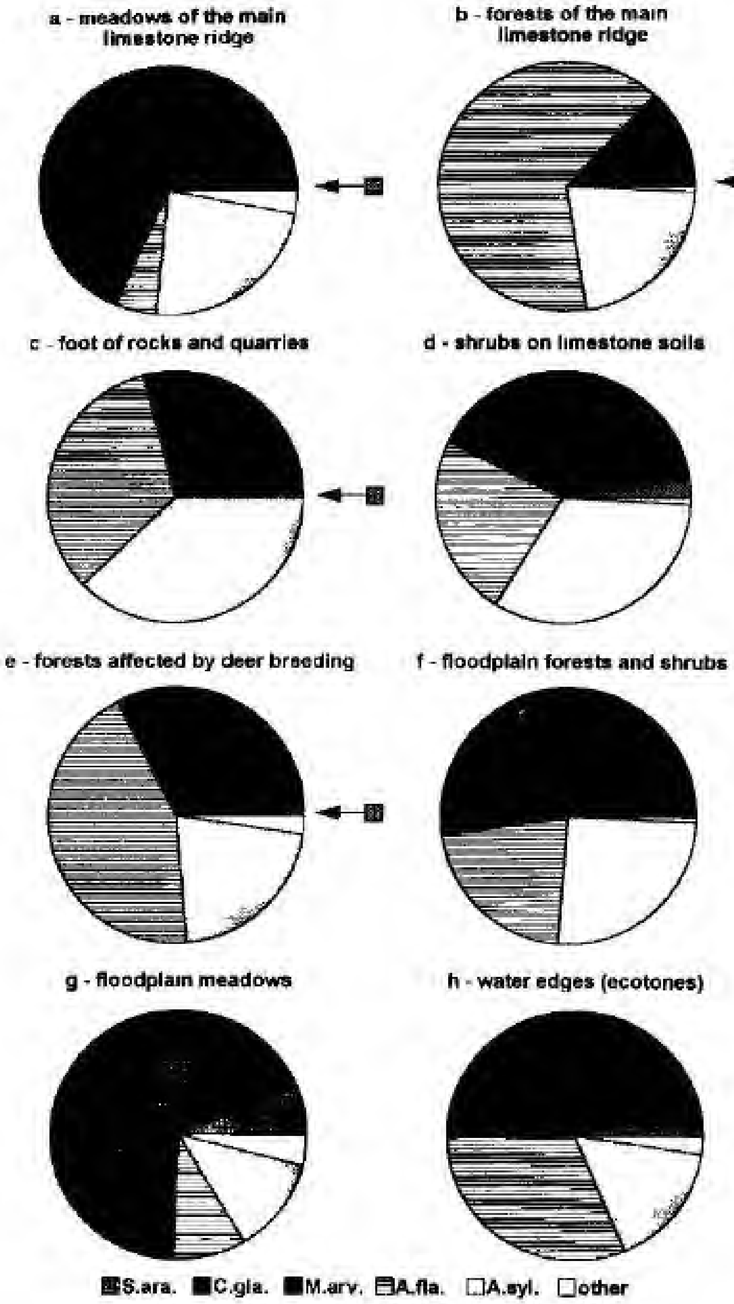

Fig. 2. Species dominance of small mammals in standard line trapping sample, with respect to biotopes

Tab. 2 Relative abundance and species diversity of small mammals in the standard line trapping sample, with respect to biotopes. Explanations: a – meadows of the main limestone ridge, b – forest of the main limestone ridge, c – foot of rock and quarries, d – shrubs on limestone soil, e – forest affected by deer breeding, f – floodplain forest and shrubs, g – floodplain meadows, h – water edges (ecotones), RA – relative abundance, catch per 100 trap-nights

Biotope	a	b	c	d	e	f	g	h
trap–nights	1380	1140	1020	1080	1740	1251	820	1140
specimens (n)	192	147	148	133	178	164	129	135
total RA	13.9	12.9	14.5	12.3	10.2	13.1	15.7	11.8
T. europaea	0.1	–	–	–	–	–	–	–
S. araneus	0.1	0.1	0.1	0.3	0.1	–	1.0	0.4
S. minutus	0.1	–	–	–	0.1	–	–	–
C. suaveolens	0.3	0.1	–	–	0.1	–	–	–
C. glareolus	1.1	1.6	3.7	1.9	2.7	6.6	2.6	5.0
M. arvalis	8.3	–	0.4	3.1	0.6	0.3	8.2	0.5
M. subterraneus	–	–	–	0.1	0.1	–	–	0.1
M. minutus	–	–	–	–	–	–	0.6	0.2
A. flavicollis	0.7	8.3	4.8	2.9	4.5	2.8	1.5	3.7
A. sylvaticus	3.3	2.8	5.5	4.1	2.2	3.4	2.0	1.9
M. musculus	–	–	–	–	–	0.1	–	–
H'	1.16	0.94	1.21	1.46	1.34	1.15	1.41	1.38

ing sites we suppose that the owls hunted for their prey mostly in the territory of the biosphere reserve.

The total species diversity, 1.33, is relatively low due to the superabundant presence of *M. arvalis* in the sample of *A. otus* pellets. It is high also in both samples of *B. bubo* and *S. aluco* pellets. The samples also differ concerning mammalian species and their dominance (Tab. 3). The pellets of *B. bubo* were collected at nesting sites, thus coming from spring when adult eagle owls fed their young. Larger mammals are well represented, *M. arvalis* and *A. sylvaticus* predominating among small mammals. The pellets of *S. aluco* were collected under summer shelters of individuals (rocks, trees), only two small samples come from nest boxes. Forest species predominate in the prey, *M. arvalis* being also common. Two rare species, *Muscardinus avellanarius* and *Microtus subterraneus*, are relatively well represented. The pellets of *A. otus* come mostly from a large flock wintering at the Mikulov cementery. The high predominance of *M. arvalis* is typical of the winter diet of this species (Obuch 1989). Characteristic is the occurence of *A. microps* which is an important faunistic element of Pannonia lowlands.

Netting of bats

Bats were netted at three localitites (Fig. 1, Tab. 4), of which A and B lie close to each other and these samples were pooled to assess species dominance (Fig. 3). The nets were set over a trough with water from a spring and at forest edges in locality A, in a clearing in locality B and close to the entrance of a large cave in locality C. The species diversity of the whole sample, 3.31, is very high and its relative abundance is 18.7 individuals per 100 net-meter-nights (meters of nets per night). The diversity is highest at A, the abundance is highest at C. *Myotis nattereri* is most common in both A+B and C, but the value of its dominance is higher at C. *Myotis* and *Plecotus*

species are well represented in both samples. The main difference between them is in the fairly common occurence of *Nyctalus noctula, Pipistrellus pipistrellus* and *Barbastella barbastellus* at A+B contrary to the fairly common occurence of *Rhinolophus hipposideros* at C. This can be explained by the difference between the two collecting sites. *N. noctula* was in fact much more common at A+B than was reflected in the netted sample, since it has frequently been observed and recorded by ultrasound detectors.

Census of hibernating bats

In 1989 to 1993, a total of 621 individual bats was counted during five checks in the Na Turoldu cave (Fig. 1), of which 611 were *R. hipposideros*, 5 *Myotis emarginatus*, 3 *M. nattereri* and 2 *M. daubentoni*. The number of *R. hipposideros* seen is believed to reflect the actual abundance of the species in the hibernaculum, while the majority of individuals of other species may hibernate in hidden places inaccessible to observation.

Tab 3. Results of the analysis of owl pellets. Explanations: n – number of specimens per species of insectivores, rodents and bats; D – dominance of particular species, H' – species diversity

Species	*Bubo bubo*		*Strix aluco*		*Asio otus*		Total	
	n	D	n	D	n	D	n	D
T. europaea	6	1.6	1	0.4	–	–	7	0.2
S. araneus	–	–	3	1.2	2	0.1	5	0.1
S. minutus	–	–	–	–	3	0.1	3	0.1
C. suaveolens	2	0.5	2	0.8	1	0.1	5	0.1
C. leucodon	1	0.3	3	1.2	–	–	4	0.1
E. concolor	66	18.1	–	–	–	–	66	1.6
M. mystacinus	–	–	1	0.4	–	–	1	0.1
P. pipistrellus	–	–	1	0.4	–	–	1	0.1
S. vulgaris	6	1.6	–	–	–	–	6	0.1
S. citellus	2	0.5	–	–	–	–	2	0.1
M. avellanarius	–	–	6	2.3	–	–	6	0.1
C. cricetus	33	9.4	–	–	–	–	33	0.8
C. glareolus	6	1.6	39	15.0	43	1.2	88	2.1
A. terrestris	1	0.3	–	–	–	–	1	0.1
M. arvalis	145	39.7	71	27.3	3077	86.8	3293	79.0
M. subterraneus	–	–	7	2.7	1	0.1	8	0.2
M. minutus	–	–	–	–	23	0.7	23	0.6
A. flavicollis	1	0.3	121	46.5	18	0.5	140	3.4
A. sylvaticus	54	14.8	5	1.9	280	7.9	339	8.1
A. microps	–	–	–	–	90	2.5	90	2.2
R. norvegicus	41	11.2	–	–	–	–	41	1.0
M. musculus	1	0.3	–	–	5	0.1	6	0.1
Total	365	100.2	260	100.1	3543	100.1	4168	100.3
H'		2.57		2.10		0.80		1.33

Tab. 4. Relative abundance (RA, catch per 100 net-meter-nights) and species diversity (H') of bats in the netted sample, with respect to localities. See Fig. 1 for particulars

Locality	A	B	C	Total
net-nights	124	20	43	227
net-m-nights	1478	216	330	2024
individuals (n)	129	4	245	378
total RA	8.7	1.9	74.2	18.68
R. hipposideros	–	–	8.5	1.38
M. myotis	0.4	–	3.3	0.84
M. bechsteini	0.8	–	2.7	1.04
M. nattereri	2.0	–	24.8	5.48
M. emarginatus	0.3	–	5.8	1.14
M. daubentoni	0.3	–	11.2	2.08
M. mystacinus	0.3	–	3.0	0.69
E. serotinus	0.1	–	3.3	0.59
V. murinus	–	0.5	–	0.05
N. noctula	0.7	–	–	0.49
N. leisleri	0.1	–	–	0.05
P. pipistrellus	0.5	–	–	0.35
P. nathusii	0.1	–	–	0.05
P. austriacus	1.7	0.5	3.3	1.83
P. auritus	1.1	0.9	8.2	2.22
B. barbastellus	0.5	–	–	0.40
H'	3.29	1.50	2.88	3.31

Additional data on mammalian species

Ondatra zibethicus was captured at Soutěska after having entered a concrete trough below the spring from which it could not escape. The presence of at least one individual of *Castor fiber* was recorded several times since 19 March 1993 by finding freshly nibbled trees at the Křivé jezero locality.

DISCUSSION

We used several different methods of recording quantitative data when studying three mammalian taxocoenoses of the Pálava Biosphere Reserve. Each of them yields a specific image reflecting a part or group of natural mammalian populations. The combination of different methods tends to complete the knowledge of real representation of species in the studied area. Six insectivore, 16 chiropteran and 16 rodent species were found in the territory of Pálava, of which 5 rodent species were only represented in the sample of owl pellets. Supposing these five species do belong to the local fauna, the number of species represents 69.1% of the insectivore, chiropteran and rodent species that occur in the Czech Republic (Anděra & Horáček 1982, updated) and 59.3% in Austria (Bauer & Spitzenberger 1983). Other species, not represented in our

material, possibly inhabit the territory of Pálava. Most probable is the occurence of *Neomys fodiens*, three specimens of which were trapped in the Sedlec Bay of Nesyt fishpond (Pelikán & Hodková 1977, cf. also Fig. 1).

Šebela (1980) sampled small terrestrial mammals of the Pavlovské vrchy Hills by means of quadrat as well as line trapping. All 7 species of his material are represented in our sample. Quadrat trapping resulted in estimating the population densities by the same method as that used by us. The total average abundance was 13.3, the average abundance of *A. flavicollis* 5.2 and *A. sylvaticus* 3.4 specimens per hectare; the values are a little lower but of the same order as the values found by us.

Gaisler et al. (1990), has already reported on *Myotis blythi* and *Myotis brandti* recorded in the Na Turoldu cave. These two species increase the number of bats found in the Pálava territory to 18 species. Concerning rodents, the occurence of *Glis glis* and *Eliomys quercinus* is theoretically possible but there have been no records of them and they are missing in the sample of owl pellets. The recent occurence of *C. fiber* is of particular importance. The process of its reintroduction in Austria was described in detail by Spitzenberger (1988). The beavers migrated from Austria to S-Moravia where they were first recorded in 1986. In 1992 they were found at seven localities and they continue to spread (Zajíček & Vlašín 1992).

Three main groups of our samples (line trapping, owl pellets and netting) differ in both number of species and species diversity, which parameters are only partly correlated with the sample size. Concerning the number of species, the ranks are owl pellets (22), netted bats (16) and line trapped mammals (12); concerning diversity, the ranks are netted bats (3.31), line trapped mammals (1.53) and owl pellets (1.33). This corresponds to the data in literature showing high species diversity, mostly 1.5 to 3.0, in samples of netted bats (Gaisler 1979, Bauerová & Zima 1988, Gaisler et al. 1990) and low species diversity, mostly 1.0 to 2.0, in samples of trapped rodents and insectivores (Dudich & Štollmann 1983, Zima et al. 1984, Anděra 1992).

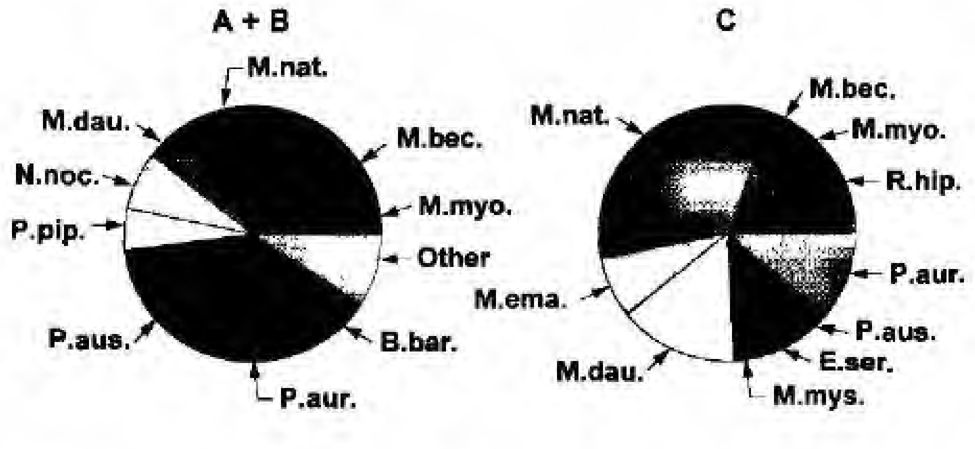

Fig. 3 Species dominance of bats netted at Soutěska (A + B) and Turold (C).

There are numerous papers on small mammals sampled in protected landscape areas similar to Pálava in size, but they do not include both terrestrial mammals and bats, or they do not give values of species diversity. Therefore, we compare our data with two papers on mammals of much larger territories. Hoi-Leitner (1989) reports 8 insectivore, 16 chiropteran and 21 rodent species actually occuring in the Neusiedlersee-Gebiet, in a territory about ten times the size of Pálava. The values of species diversity are 0.33 to 2.06 for trapped mammals and 0.84 to 1.56 for mammals from owl pellets (*Tyto alba*). The diversity of bats has not been indicated. Anděra & Červený (1994) report 8 insectivore, 17 chiropteran and 17 rodent species actually occurring in the Šumava Mts. region, in a territory about fifty times the size of Pálava. The values of diversity are 1.44 to 3.00 for trapped mammals and 1.38 to 2.50 for netted bats. Although owl pellets were analyzed, no diversity data of that sample have been indicated. The data of Hoi-Leitner resemble ours, while the data of Anděra & Červený (l. c.) differ, indicating higher diversity of terrestrial mammals than bats. A comparison with the two papers, however, implies that the diversity of the bat community is relatively very high in the territory of Pálava.

In our standard line trapping sample, the relative abundance of Soricidae is very low with respect to that of Arvicolidae and Muridae. The shrews are much more common in many samples dealt with in two the papers mentioned above than in the samples from Pálava. Concerning rodents, only four species, viz., *C. glareolus, M. arvalis, A. flavicollis* and *A. sylvaticus*, show relative abundance values higher than 4.0 in samples from different localities and biotopes. This corresponds to the conclusions of Schröpfer (1990) on the structure of European small mammal communities. According to that author, most individuals (>75%) of small mammals inhabiting a given locality belong to three species at most. According to species dominance, the communities can be classified as vole-type, mouse-type or shrew-type. In our material, mouse-type communities are most frequent, vole-type communities less frequent and shrew-type communities do not occur.

In our sample of netted bats, the relative abundance of *Myotis* and *Plecotus* species is very high with respect to the relative abundance of other species coupled. The relative abundance of *M. nattereri* and *M. daubentoni* in the sample from locality C are higher than 10.0. We assume that these values reflect a specific behaviour of the species in question with respect to the habitat (cave and rocks with many crevices) rather than their overall abundance in the region. Bauerová & Zima (1988) discussed possible causes of the high concentration of certain bat species at cave entrances during the growing season. According to these authors the bats netted under such conditions do not represent a random sample of a community bound to the environs of a cave. Very likely, this is the case of our sample from C. With some caution the samples from A and B (forest) may be considered a better rerflection of the real abundance of particular species. The caution concerns, above all, *N. noctula* which certainly is common in the forest but is numerically underestimated in the sample. *R. hipposideros* is not represented in the sample at all, perhaps because it does not forage in the forest. this species, locally extinct and endangered in many regions of Europe (Stebbings 1988), is common in the territory of the Biosphere Reserve. Its population, hibernating in the Na Turoldu cave, has increased during the last 10 years (Gaisler et al. 1990).

Acknowledgements

We thank H. Beránková, J. Brunner, J. Čápová and especially J. Ryšavý (Brno) for assistance during field research. P. Votíšek (Praha) kindly supplied the data on mammals he trapped in the Milovice forest. We also thank the staff of Administration of the Biosphere Reserve Pálava and the staff of Forestry Administration (Mikulov) for the support of our work. The whole project has been supported by the grant No 66907 of the Academy of Sciences of the Czech Republic.

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Acta Soc Zool Bohem **60** 25–30, 1996
ISSN 0862–5247

Annual course of cave visitation by bats (Mammalia: Chiroptera) in the Bohemian Karst (Czech Republic)

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Received January 12, 1996 accepted February 29, 1996
Published April 5, 1996

Abstract. Results of 64 bat nettings at entrances to galleries in the quarry Kozel (Bohemian Karst, Czech Republic) in 1988, 1990, 1991 and 1993, are presented Every season, 16 nettings were undertaken from April to November at 10–16-day intervals In total, 9 species were ascertained *Myotis myotis, M daubentoni, M mystacinus, M nattereri Barbastella barbastellus, Eptesicus serotinus, Plecotus austriacus, P auritus* and *Rhinolophus hipposideros* Among individual species *M myotis* was the most numerous (D=54,9–67,9%) The data revealed (1) the phase of rather more intensive galleries visitation by bats from April to June, (2) the phase of minimum intensity of the galleries visitation during July and (3) the phase of maximum intensity of the visitation of galleries by bats during August and September

Cave visitation, annual course, bats, Bohemian Karst, Czech Republic

INTRODUCTION

During last 30 years, the attention of a number of authors has been concentrated on the catching bats in special mist-nets during their flight activity In Czech Republic, the results of netting bats at the underground sites have been discussed by Gaisler (1973, 1975), Horáček (1971, 1975), Anděra, Zbytovský & Burger (1992) and namely Horáček & Zima (1978), who also netted bats at the cave entrances to caves in the Bohemian Karst

The present paper provides a preliminary survey of the results obtained in 1988, 1990, 1991 and 1993 The aim of the study was to analyze an annual course of visitation of the underground sites visitation by bats (roaming movements), namely to be compared with results of Horáček & Zima (1978) At last but not least, the paper supplements as yet available faunal and ecological data on bats of the respective protected area (e g , Horáček 1979, 1985, Hanzal & Průcha 1988, 1992, Průcha & Hanzal 1989) and to compare it with consequently data from Moravian karst (Bauerová & Zima 1988a, 1988b) and South Moravia (Hanák et al 1996)

MATERIAL AND METHODS

Netting were performed at 2 entrances of an underground gallery system situated in the quarry called Kozel near the village Srbsko (Central Bohemia, SW of Prague, 49° 57' N and 14° 10' E, of the zoology mapping grid quadrat 6050) The galleries are ca 450 m of total length and their average gauge is 3×3 m The entrances are opened into a valley of the Berounka River In total, 64 nettings in years 1988, 1990, 1991 and 1993 (in 1989 and 1992 catching was carried out only occasionaly and the data are not included in this paper) Every season, 16 nettings were performed from April to November, i e , two netting efforts monthly (at 10–16-day intervals), are in the same two entrances, situated in the quarry The nets were spread in the same way to cover the entrances totally The nettings started before nightfall and lasted by the first light In the bats captured, time of capture, sex, length of forearm, age, weight, direction of flight (in/out) were recorded All the specimens were released in 30 min Most of animals captured were banded (99%) In total 620 captures were obtained, incl 48 recoveries (7 7%) Most of bats entered the cave from outside it only a few animals (3%) were netted during their flight off

Tab. 1. Review of the total catch of bats netted at the entrance of the galleries in the quarry Kozel in 1988–1993. Explanation: n – number of catching bats, D – index of dominance

Species	1988		1990		1991		1993		1988 - 1993	
	n	D	n	D	n	D	n	D	n	D
Myotis myotis	103	62.8	73	54.9	111	64.9	102	67.1	389	62.8
Barbastella bararbastellus	24	14.6	16	12.0	12	7.0	10	6.6	62	10.0
Myotis daubentoni	12	7.3	12	9.0	12	7.0	15	9.9	51	8.2
Plecotus austriacus	4	2.5	15	11.3	10	5.8	6	3.9	35	5.6
Plecotus auritus	4	2.5	11	8.3	14	8.2	4	2.6	33	5.3
Eptesicus serotinus	11	6.7	3	2.2	–	–	7	4.6	21	3.4
Myotis nattereri	3	1.8	3	2.2	7	4.1	5	3.3	18	2.9
Myotis mystacinus	3	1.8	–	–	2	1.2	3	2.0	8	1.3
Rhinolophus hipposideros	–	–	–	–	3	1.8	–	–	3	0.5
total	164	100.0	133	100.0	171	100.0	152	100.0	620	100.0

RESULTS

In total, 9 bat species were found, viz. *Myotis myotis* (Borkhausen, 1797), *Myotis daubentoni* (Kuhl, 1819), *Myotis mystacinus* (Kuhl, 1819), *Myotis nattereri* (Kuhl, 1818), *Barbastella barbastellus* (Schreber, 1774), *Eptesicus serotinus* (Schreber, 1774), *Plecotus austriacus* (Fischer, 1829), *Plecotus auritus* (Linné, 1758) and *Rhinolophus hipposideros* (Bechstein, 1800) (Tab. 1).

In individual seasons a number of species varied from 7 (1990) to 8 (1988, 1991 and 1993). It is obvious that the highest number of captures was in 1991 (171) while the lowest one in 1990 (133). A predominant species in the bat community was *Myotis myotis*. Among eudominant species during the individual seasons, *Barbastella barbastellus* (1988, 1990) and *Plecotus austriacus* (1990) should be mentioned. The former species can be considered a dominant according to the results from the whole period. The other species found at the site should be classified in lower classes of dominance. A clear abundance trend occured in *Barbastella barbastellus* which numbers gradually decrease.

An annual course of cave visitation has been evaluated either for a total community (Fig. 1) and for the most abundant species, i. e., *Myotis myotis* (Fig. 2). Three sugest can be clearly distinguished.

(1) The phase of a more intensive cave visitation by bats from April to June, which is characterized by increasing numbers of entering bats in April and May, folloved by a decrease during June.

(2) The phase of minimum intensity of the cave visitation during July

(3) The phase of maximum intensity of the galleries visitation by bats during August. It is apparently characterized by a dramatic increase in numbers in late August/early September, followed by a continual decrease during September, October and November.

Despite of some exeptions we can conclude that activity of bats on a study locality should by described by two peaks, with the first (submaximum) one during phase (1) and with the second (maximum) one during phase (3).

Figs 1 and 2 shows that the individual phases cannot be sharply distinguished and can have some time delays in individual seasons. As suggested by the results from 1988. Comparing with the other seasons there was a time shift of ca. 2 weeks (the first peak in the second half of July and with the second peak in the half of September).

DISCUSSION

The bat fauna of the Bohemian Karst Protected Lanscape Area has been intensively studied for a number of years, practically without interruption since 1955 (Hanák et al. 1962). Nevertheless, most of data were collected during the winter season (e. g. Horáček 1979, Bárta et al. 1981, Hanák & Figala 1963, Hanzal & Průcha 1988, Průcha & Hanzal 1989). In total, 15 bat species were found to occur in this region. All the species caught during the nettings regularly occur in this region during the winter, with almost the same patterns of dominance (see also Hanzal & Průcha 1988). The only results of netting bats from the Bohemian Karst were as yet published by Horáček & Zima (1978), who netted bats at the entrance to the „Srbské jeskyně" caves. It is situated nearly our locality. Six bat species were registered by these authors: *Myotis myotis, M. daubentoni, M. emarginatus, Plecotus auritus, P. austriacus, Barbastella barbastellus* and *Rhinolophus hipposideros*. The difference in species composition between their and our results are not essential and concern the rare species only (absence of *M. emarginatus* and occurence of *M. mystacinus, M. nattereri and Eptesicus serotinus* in our locality). Horáček & Zima (l. c.) also discussed the annual course of cave visitation. They interpreted the net-revealed data as an evidence of roaming movements of bats and divided whole the cycle in spring, summer, autumn and winter phases. Our results from April netting show that the period of the spring roaming movements has not been expressed at the site studied by us. The above mentioned authors conclude, that in a greater extent, it occur in a few species only – e. g. *Plecotus auritus*. This species, as well as the species of similar in ecological requirements for wintering (e. g. *Plecotus austriacus* and *Barbastella barbastellus*) occur irregularly during winter on the study locality or are present in very low numerous there. Summer roaming movements could be (due to the absence of roaming movements, this phase is in our material characteristic by a continual increase in numbers during April and May, after decrease to a minimum level is an increase in number entering bats apparent in late July) classify to phase (1) and (2) as defined in this study. The phase 3 fully correspondend with the phase of autumn roaming activity described by Horáček & Zima (l. c.). The more detailed analysis of the individual phases will be carried out after collecting a more extensive material. In the moment, we can suppose that annual course of cave visitation could be in various extent modified by specifice features of individual underground sites, weather conditions in individuals seasons and other factors.

Acknowledgements

The authors wish to thank the staff of the Bohemian Karst Protected Landscape Area Administration and collaborators from the Czech Bat Conservation Trust, who participated in field work.

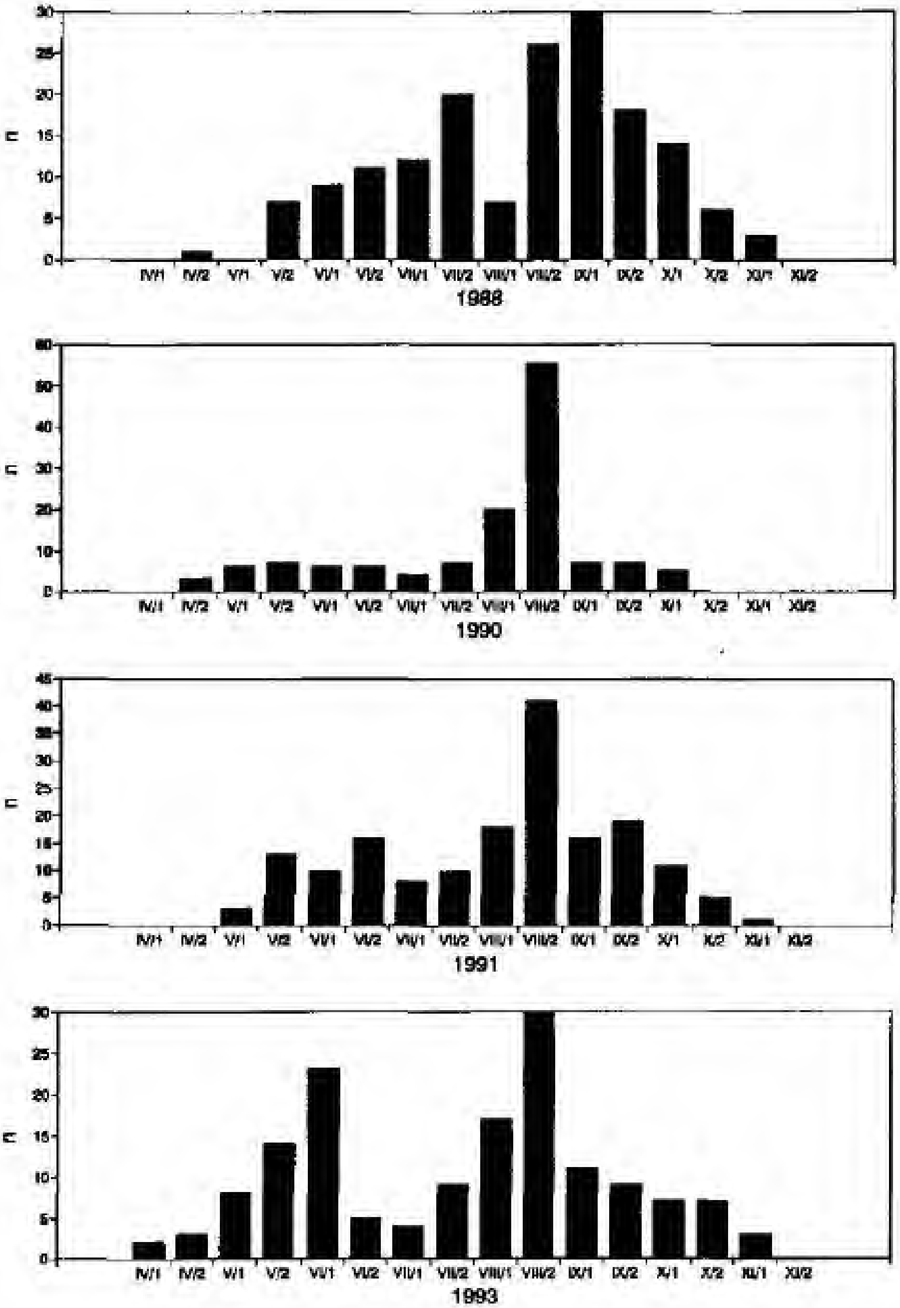

Fig. 1. The roaming activity of the all bat communities at the entrances of the galleries in the quarry Kozel in 1988, 1990, 1991 and 1993 (n – number of catching bats).

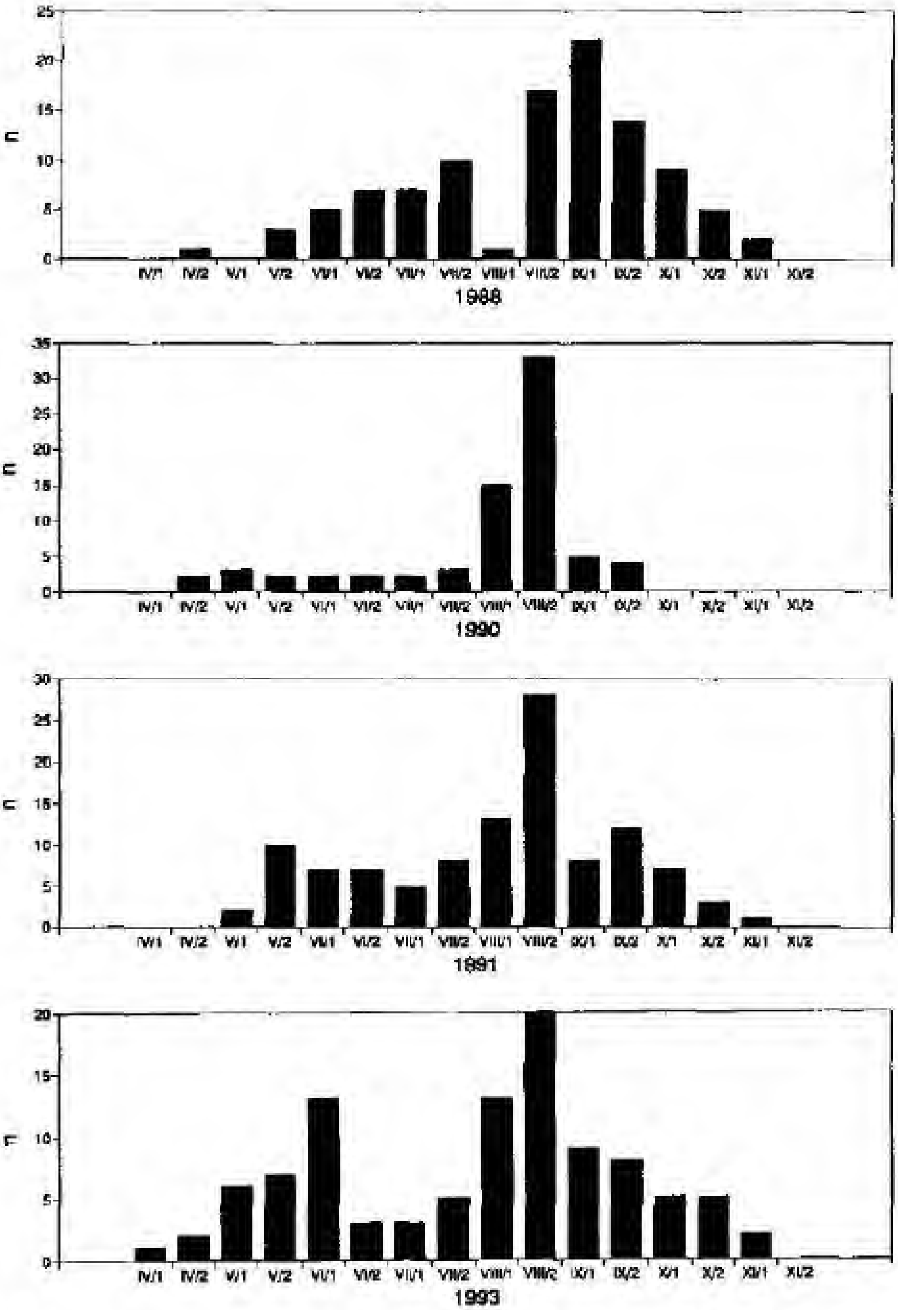

Fig. 2 The roaming movements of the *Myotis myotis* at the entrances of the galleries in the quarry Kozel in 1988, 1990, 1991 and 1993 (n – number of catching bats)

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Acta Soc. Zool. Bohem. **60**: 31–36, 1996
ISSN 0862-5247

Interspecific difference in proportions of the praesacral spine in Canidae (Mammalia: Carnivora)

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Received November 19, 1995, accepted February 29, 1996
Published April 5, 1996

Abstract. Sizable differences were found in a relative weight of praesacral vertebrae in selected species of canids (10 wild-living species, a domestic dog, a cross-breed). They are described and discussed under the standpoint of prospective functional correlations between a type of the praesacral spine and certain biological activites of the species compared. The attention is drawn to correlations between weight proportions of the spine and systematic position of the species.

Adaptive correlations, Canidae, praesacral spine, relative weight

INTRODUCTION

„The dog family is often said to be an unusually conservative and uniform group. This has proved to be particularly true of the postcranial skeleton." That is what Milton Hildebrand wrote in one of his two extensive studies bearing of morphometric characters of the postcranial skeleton in canids (Hildebrand 1952, 1954; see also Thenius 1972). The quotation cited seems to be undoubted as far as longitudinal measures of examined bones, skeletal complets and of some other morphological characters are taken into account. Somewhat different results follow, however, if values of the weight are used for the aims of characterizing the skeletal proportions. This reality may be caused by the fact that methods analyzing weight of bones are more accurate than those based on longitudinal measures, especially in the bones like the vertebrae where the correct data giving a true image of the real size of the bone are available with difficulties only due to a lot of existing processes and grooves. A special importance of the weight to comparisons made in higher taxonomic units (orders) is mentioned in a literature (Grassé 1967, etc.); analogous differences, however, may be stated also at a specific level. Proportional differences among the praesacral vertebrae in a dog family, the study of which is an objective of the present paper, may be presented as an example of such a situation.

MATERIALS AND METHODS

Twenty four skeletons have been examined for the aims of the present study as follows: domestic dog, *Canis familiaris* Linné, 1758 (= *Canis lupus f. familiaris*) – 3 specimens; gray wolf, *Canis lupus* Linné, 1758 – 1 sp.; cross-breed *C. lupus* × *C. familiaris* – 1 sp.; european fox, *Vulpes vulpes* (Linné, 1758) – 3 sp.; corsac fox, *Alopex corsac* (Linné, 1758) – 2 sp.; fennec fox, *Fennecus zerda* (Zimmermann, 1780) – 2 sp.; racoon-dog, *Nyctereutes procyonoides* (Gray, 1834) – 1 sp.; maned wolf, *Chrysocyon brachyurus* (Illiger, 1811) – 2 sp.; bush dog, *Speothos venaticus* (Lund, 1842) – 6 sp.; asiatic wild dog, *Cuon alpinus* (Pallas, 1811) – 1 sp., african hunting dog, *Lycaon pictus* (Temminck, 1820) – 1 sp.; big-eared fox, *Otocyon megalotis* (Desmarest, 1821) – 1 sp. Most cadavers originate from Zoological Gardens Praha and Dvůr Králové, one specimen (cross-breed) from a Militatary veterinary station; remaining skeletons from stores of a ceased firm V. Frič, Praha. The restricted number of the material examined seems to be a reason of a careful evaluating the results. Nevertheless, it is to be mentioned in this connection that existing fluctuations of the characters measured are rather low and, thus, they *cannot influence seriously the essential features of the results, nor in cases when the age of specimen examined varies in* rather sizable range (Heráň 1993: 66, 72).

Vertebrae of the praesacral spine (i e , cervical, thoracal, and lumbal ones) have been weighed using a technical balance, with a punctuality of 0 005 g and 0 01 g regarding an increasing size of species, respectively Their relative weight (R) has been evaluated by referring a weight of the respective vertebra (V_n) to a total weight of the praesacral spine (S)

$$R = V_n \times 10 / S$$

The present method is well known and widely used a long time in osteology (Delmas et al 1959, 1960, etc) Analogically the relative weight of vertebrae may be expressed also in per cent of the weight of the heaviest vertebra as shown in Fig 3

As the respective computations are made separately in each specimen when using this method, eventual slight distinctions in the mode of processing skeletons cannot influence results obtained On the other hand however, the material examined should be entirely in a sound condition as various exostoses or destructions of the bone tissue can change a standard course of the curve very notedly (Fig *1*)

RESULTS

The praesacral spine in canids is composed of standard number of 27 vertebrae (7 cervical, 13 thoracal, 7 lumbal) A total weight of them fluctuates in limits given as 10 g in *Fennecus zerda* and 405 g in *Canis lupus* regarding the species examined As for the respective sections, their weights (C T L) may be expressed by a ratio 39 29 32 on the average The thoracal spine presents the steadiest values as compared with the remaining two sections relative weights of which fluctuate sizably (32 1% to 52 2% in the cervical, 19 8% to 39 6% in the lumbal spine) in various species A marked interspecific variation is expressed especially in the cervical section while, in general, its weight corresponds to about 55±10% of the T+L total weight, this value reaches up to 139% in *Speothos venaticus* and to about 80% in two following species (Tab 1A, 1B)

The relative weights of praesacral vertebrae, if arranged successively one by another, constitute a more or less continual value sequence*) with two marked peaks The first peak corresponds to the weight of the largest cervical vertebra (C2 – 20×, C1 – 3×), the second to the largest lumbal one (L5 – 12×, L6 – 8×, L4 – 3×), a depression of the values occurs regularly in the position of thoracal vertebrae (usually T6 to T10)

Two basal types of the value sequence result if the levels (heights) of the both peaks are related to each other

(1) The cervical peak is notedly heigher than the lumbal one their values being separated markedly from each other by a line which represents 5% of the total weight of the praesacral spine (Fig 2A) The respective values differ rather markedly from each other in the relevant species (*Speothos venaticus, Otocyon megalotis, Nyctereutes procyonoides, Cuon alpinus, Lycaon pictus, Chrysocyon brachyurus*), especially those of the cervical vertebrae ratio cervical to lumbal peak values varies between 4 00 and 1 27 in this group

(2) The lumbal peak is higher than the cervical one Their values lay both over the line of 5% level (Fig 2B), ratio cervical peak to lumbal peak is lower than 1 0 Relevant species of group *Vulpes vulpes, Fennecus zerda Alopex corsac*

The two above types of the value sequence differ markedly from each other especially in extremely formed species (*Speothos venaticus, Alopex corsac* – see Fig 3) In the other canids the adaptations are not so much conspicuous as in the foregoing case and the value sequences draw near each other *Canis lupus* and *Canis familiaris*, where the cervical peak is slightly higher than the lumbal one and the values of them both lay over the line of 5% level, are typical crossing species in this sense

*) The respective values are discontinuous however, they are presented as components of coherent lines in Figs 1–3 because of the easier orientation

Tab 1 Proportions of the praesacral spine in Canidae A – weight of spine segments, ratio cervical thoracal lumbal, B – cervical spine in per cent of thoracolumbal spine (weight), C – cervical spine in per cent of thoracolumbal spine (length, computed according to data given by Hildebrand, 1952), D – ratio 3 largest cervical vertebrae to 3 largest lumbal vertebrae (weight), E – ratio cervical spine total to lumbal spine total (weight)

Species	A	B	C	D	E
Speothos venaticus	58.2 22.0 19.8	139.0	37.7	4.00	2.93
Otocyon megalotis	45.1 26.4 28.5	82.2	42.4	2.02	1.58
Nyctereutes procyonoides	44.6 26.7 28.7	80.6	42.7	1.91	1.56
Cuon alpinus	40.6 29.9 29.5	68.3	35.4	1.59	1.37
Lycaon pictus	40.2 30.0 29.8	67.2	38.4	1.59	1.35
Chrysocyon brachiurus	38.4 30.7 30.9	62.3	47.7	1.27	1.24
Canis lupus	35.6 31.9 32.5	55.3	38.6	1.25	1.10
Canis lupus × *C familiaris*	34.5 33.3 32.2	52.6	–	1.17	1.10
Canis familiaris	32.1 32.4 35.5	46.4	–	1.05	0.90
Fennecus zerda	34.3 30.1 35.6	52.2	38.8	0.98	1.00
Alopex corsac	33.7 26.7 39.6	50.1	34.3	0.94	0.85
Vulpes vulpes	32.9 31.6 35.5	49.0	37.7	0.93	0.93

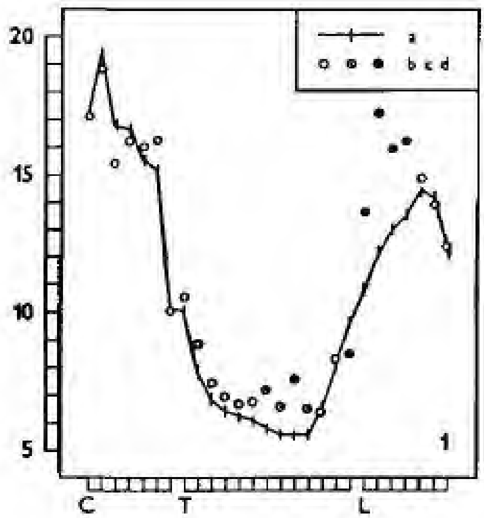

Fig 1 *Chrysocyon brachyurus*, weights of praesacral vertebrae in standard material (a) and in specimen with pathological changes (spondylosis deformans) of spine (b–d), middle sized (c) and intensive (d) development of exostoses, destruction of vertebral body in T 13 Abscissa – cervical (C), thoracal (T) and lumbal (L) vertebrae Ordinate – weight of vertebrae in grams

DISCUSSION AND CONCLUSIONS

Considerable differences among the sequences of relative vertebral weights in various species of canids evoke a question of their function especially because of the reason that, for the mostpart, they do not correspond to analogical longitudinal relations which were computed regarding the data given by Hildebrand (1952). Whilst the greatest relative length of the cervical spine has been found in *Chrysocyon brachyurus*, and *Speothos venaticus* occurs near the end of the succession in this respect (the shortest neck has *Alopex corsac*), the highest relative weight is explicitly found in the cervical spine of *Speothos venaticus* where it amounts to incredible 139% as related to the weight of the thoracolumbal section (T+L). Values of the relative weight of cervical spine in *Otocyon megalotis* (82.2%) and *Nyctereutes procyonoides* (80.6%) closely

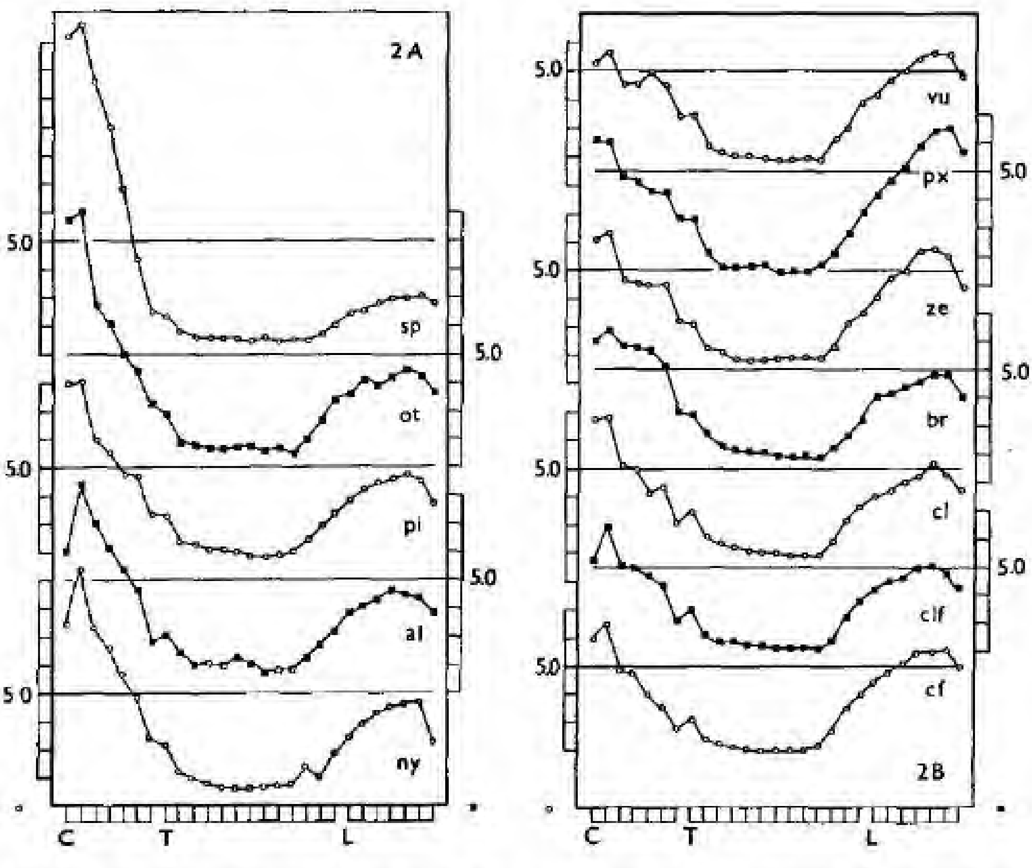

Fig. 2 Proportions of praesacral spine in canids examined. Abscissa – see Fig. 1. Ordinate – relative weights of vertebrae in per cent of praesacral spine total, scale is divided after 1%, a level of 5% is indicated by horizontal line in each species (left for circles, right for rectangles). Open rectangles in Cuon indicate hypothetic values of respective vertebrae. Explanation: al – *Cuon alpinus*, br – *Chrysocyon brachyurus*, cf – *Canis familiaris*, clf – cross-breed *C. lupus* × *C. familiaris*, cl – *Canis lupus*, ny – *Nyctereutes procyonoides*, ot – *Otocyon megalotis*, pi – *Lycaon pictus*, px – *Alopex corsac*, sp – *Speothos venaticus*, vu – *Vulpes vulpes*, ze – *Fennecus zerda*.

follow those of the bush dog while the long-necked *Chrysocyon brachyurus* (relative neck weight 62.3%) appears only round one half of the canids investigated (Fig. 2, Tab. 1B, C).

Sequences of relative vertebral weights of *Speothos venaticus* and *Alopex corsac* (Fig. 3) represent two limits of variation in the species examined. They indicate large interspecific differences in mechanical demands to the praesacral spine as well as an extent of strains in the respective spine segments. Such differences among the characters in nearly related species are usually explained regarding the body size, specific modes of locomotion, nutrition, as well as a systematic position of the respective species.

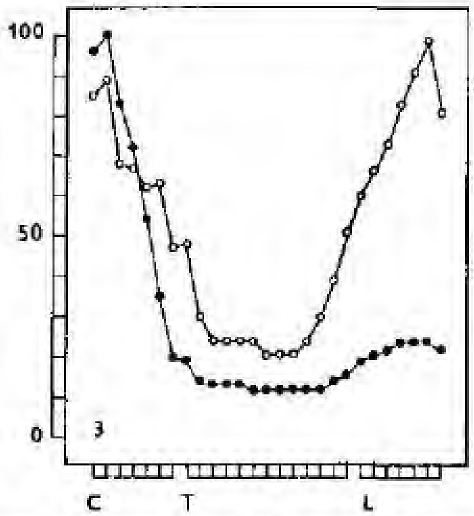

Fig. 3: Relative weight of praesacral spine in extremely differing from each other *Speothos venaticus* (shaded circles) and *Alopex corsac* (open circles). Abscissa – see Fig. 1. Ordinate – relative weights of vertebrae in per cent of the largest one in each species (= 100 %).

According to Hildebrand (1954), the skeleton of *Vulpes vulpes* is as much modified for running as that of any canid. Besides, strenghtening of the lumbal segment, as appeared in foxes first of all, indicates an advanced supporting function of a region of pelvic extremities as manifested, for example, in jumping activities of canids catching mice. *Speothos venaticus* is said to have a high affinity to the water environment (Bates 1944, Langguth 1972, Senglaub 1981) which might be well given into a correlation with the relatively short but very strong and massive neck spine in this species. A long and relatively light cervical spine of *Chrysocyon brachyurus*, too, might be explained as an adaptation to moving in the high grass vegetation (Miller 1930, etc.). On the whole, however, no pronounced correlation between the neck size and a specializated ways of locomotion has been regularly found in most species examined.

Several morphological adaptations coincide also with various kinds of a nutritive behaviour. *Speothos venaticus* in which such adaptations are manifested with a great distinctness, may be presented as an example of these connections. Characters of the spine sections (length, weight) in this species are considered adaptive phenomena connected mainly with its well known preferring predation of large prey animals, viz. *Hydrochoerus hydrochaeris* und *Cuniculus paca* first of all (Cabrera & Yepes 1940, Langguth 1972, Deutsch 1983, etc.). Such an activity represents

a marked strain of the neck section in the bush dog, especially as compared with canids of larger body size.

Such a notedly pronounced functional correlation between morphological characters of the spine and a type of the nutritive behaviour, however, does not exist in most remaining canids under question. On the contrary, several species may manifest quite opposite correlations: whilst *Lycaon pictus* and *Cuon alpinus* prey upon large game (Senglaub 1981, Grzimek 1972) and their relative weight of the cervical spine is not heightened markedly, the respective neck weight of *Nyctereutes procyonoides* and *Otocyon megalotis* is very high in the both species although they feed prevalently on evertebrates and small vertebrates (Müller-Using 1972).

Another aspect of appreciating spine proportions has been applied by Huber et al. (1966) in a study where a length of caudal vertebrae in various mammalian orders was expressed in per cent of the longest tail vertebra in each species: resulting curves, in general, agreed to each other in species according to their classification. Results of analogical explorations made by the author, however, are somewhat different. Only the lowest values of index C : L may be attached almost conformably with all foxes (related genera *Vulpes*, *Fennecus* and *Alopex*) and with dogs (genus *Canis*) which are related to the former (Thenius 1972). Systematic aspect like those, which bear upon a distribution of the remaining values, are not so evident even when eventual adaptive changes of them are taken into account. This concerns, e.g., the heavy neck spine of *Otocyon megalotis* and *Nyctereutes procyonoides* the close relationships of which to *Speothos venaticus* are mentioned in a literature.

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Acta Soc. Zool. Bohem. 60 37–42, 1996
ISSN 0862–5247

New data on the birds of Syria

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Received January 2, 1996, accepted February 29, 1996
Published April 5, 1996

Abstract. Observations on 69 bird species made in Syria in 1995 are presented. Two of the species, *Larus minutus* and *Lanius excubitor*, are new to Syria, raising thus the number of bird species known from Syria to 219

Distribution, Aves, Syria

INTRODUCTION

The birds of Syria are known only on the basis of anecdotical evidence (Carruthers 1910, Clarke 1924, Meinertzhagen 1935, Hollom 1959, Rappe 1971, Kumerloeve 1972b, Jeffery 1978, MacFarlane 1978, Pyman 1978, Wallace 1984, Baumgart 1991a, b, 1993, Baumgart & Kasparek 1992). Syria (185 000 km^2) continues thus to be an ornithological terra incognita (see Baumgart 1993). The available data were summarized by Kumerloeve (1967, 1968, 1969, 1972a), and Baumgart & Stephan (1986, 1987, 1994). More general references include Hüe & Etchécopar (1970) and Hollom et al. (1988).

Below, I present my observations of Syrian birds made during a trip on 28 September – 8 October 1995. Included are also a few observations made in Syria by Petr Benda (PB) between 29 April and 17 May 1995. Unsigned observations are mine (JM)

Sequence and nomenclature of the species follows Voous (1977) Most of the visited localities are listed in Baumgart & Stephan (1986, 1994). Spelling of geographical names is different in different maps. For clarity, I follow spelling used by Baumgart & Stephan (1986, 1994) where possible. Localities not mentioned by Baumgart & Stephan (1986, 1994) are as follows (see Fig 1)

Afrin. A tall at Afrin Suyn river south of Afrin. Meandering stream surrounded by a narrow swampy belt in dry steppe
As Sayyal Blind arms of Euphrates rives, with reed stands and open mud flats, near the village of As Sayyal
Qalaat el-Hosn: I use the Arabian name for this castle, which is called by Baumgart and Stephan (1986, 1987, 1994) Crak des Chèvaliers (Kurd-French name)
Qalaat Rabbah Ruin of an ancient Arab castle, ca. 40 km east of Deir-ez-Zoor.
Qanawat. Dense shrubs sparkled with small fields in Doruz Mountains near the village of Qanawat.
Tadmur. Arabian name for the Ancient Palmyra.

SPECIES LIST

Little grebe *Tachybaptus ruficollis* (Pallas): Several individuals were seen on 6.x. on a blind arm of Euphrates river at As Sayyal.

Rosy pelican *Pelecanus onocrotalus* Linnaeus: A flock of ca. 70 individuals circled above Qalaat el-Hosn on 30.iv. (PB).

Little egret *Egretta garzetta* (Linnaeus): Several individuals were observed on 28.ix. at Afrin Suyn, and on 8.x. at Euphrates dam. Little Egrets were known only from spring migration in

Syria so far (Baumgart & Stephan 1986, 1994). This is thus the first evidence for a fall migration. Also in Jordan, little egrets are much less common in the fall than on spring migration (Andrews 1995).

Great white egret *Egretta alba* (Linnaeus): An individual was seen on 28.ix. at Afrin Suyn. This is the earliest fall observation for Syria.

Grey heron *Ardea cinerea* Linnaeus: An individual was seen flying over dry steppe at Apamé on 30.ix.

Black stork *Ciconia nigra* (Linnaeus): An individual flew southwards over Apamé on 30.ix. This is the third and earliest fall observation of this migrant. The previous ones were made on 2.x. 1982 and 29.x. 1980 at Damascus (Baumgart & Stephan 1986, 1994).

White stork *Ciconia ciconia* (Linnaeus): A flock of ca. 100 individuals circled over Maalula on 17.v. (PB).

Northern shoveler *Anas clypeata* Linnaeus: A flock of ca. 10 individuals landed on a small desert dam at Salim on 4.x. This is the earliest fall observation from Syria.

Black kite *Milvus migrans* (Boddaert): Single individuals were seen on 4.x. at Tadmur, and on 6.x. at As Sayyal.

Marsh harrier *Circus aeruginosus* (Linnaeus): An individual was seen at blind arms of Euphrates river at As Sayyal on 6.x.

Buzzard *Buteo buteo* (Linnaeus): Individuals were observed on 1.x. at Maalula, 3.x. at Tall Shebab, and on 5.x. at Tadmur.

Spotted eagle *Aquila clanga* Pallas: An immature individual was seen flying at Afrin Suyn on 28.ix.

Osprey *Pandion haliaeetus* (Linnaeus): An individual was seen fishing in the Euphrates dam on 8.x.

Kestrel *Falco tinnunculus* Linnaeus: Observed on 29.ix. in Halab, and on 7.–8.x. at Russafa.

Moorhen *Gallinula chloropus* (Linnaeus): Common on blind arms of Euphrates river at As Sayyal (6.x.).

Black-winged stilt *Himantopus himantopus* (Linnaeus): A few individuals were seen on 6.x. at As Sayyal, and on 6.–7.x. on a small island in Euphrates river at Zenobia. This is the first evidence for a fall migration of this species through Syria.

Plover *Charadrius alexandrinus* Linnaeus: A flock was seen on 6.x. at As Sayyal.

Dunlin *Calidris alpina* (Linnaeus): A flock was observed on 6.x. at As Sayyal. This is the third observation of this species in Syria. Also the previous two (24.x. 1982 at Ghuzlanie, and 28.x. at Homs Lake) were limited to the period of fall migration (Baumgart & Stephan 1986).

Spotted redshank *Tringa erythropus* (Pallas): Several individuals were seen on 6.x. at As Sayyal. This is the earliest fall observation of this species in Syria (Kumerloeve 1968, Baumgart & Stephan 1986).

Redshank *Tringa totanus* (Linnaeus): Several individuals were recorded on 6.x. at As Sayyal. This is the first fall observation of this species in Syria. So far, redshanks were known from Syria as spring migrants only (Baumgart & Stephan 1986, 1994), although two observations from December and February point toward the possibility, that redshanks overwinter in Syria in small numbers.

Common sandpiper *Actitis hypoleucos* (Linnaeus): Several individuals were seen on 6.x. at As Sayyal.

Great black-headed gull *Larus ichthyaetus* Pallas: Several individuals were repeatedly seen on 6.–7.x. at Euphrates river near Zenobia. This is the earliest fall observation of this species in Syria, which is known to rarely overwinter there (Baumgart & Stephan 1986, 1994).

Little gull *Larus minutus* Pallas: Several individuals were observed on 6.x. at blind arms of Euphrates river at As Sayyal. This is the first record of this species for Syria.

Herring gull *Larus argentatus* Pontoppidan: Several individuals were observed on 30.ix. at the sea shore Tartous, and on 8.x. on Euphrates dam. Taxonomy of the *Larus argentatus* complex is not satisfactorily resolved yet. Individuals found at the sea and in regions near to it will probably belong to *Larus (argentatus) cachinnans* Pallas, which is now mostly treated as a separate species. Less evident is the origin of herring gulls wintering inland at Euphrates river. They potentially could belong to the armenian herring gull *Larus (argentatus) armenicus* Buturlin, whose (sub)specific validity has been supported recently (Buzun 1993). Andrews (1995) considers winter occurence of this form in Jordan probable, and lists a single definite record from 12 April 1992 at Aquaba.

Rock dove *Columba livia* Gmelin: Rock doves or feral domestic doves were seen on 1.–2.v. in Tadmur (PB), on 5.x. in Tadmur (JM), and on 1.–2.x. in Maalula (JM).

Collared dove *Streptopelia decaocto* (Frivaldszky): Several individuals were seen on 29.–30.ix. in Apamé.

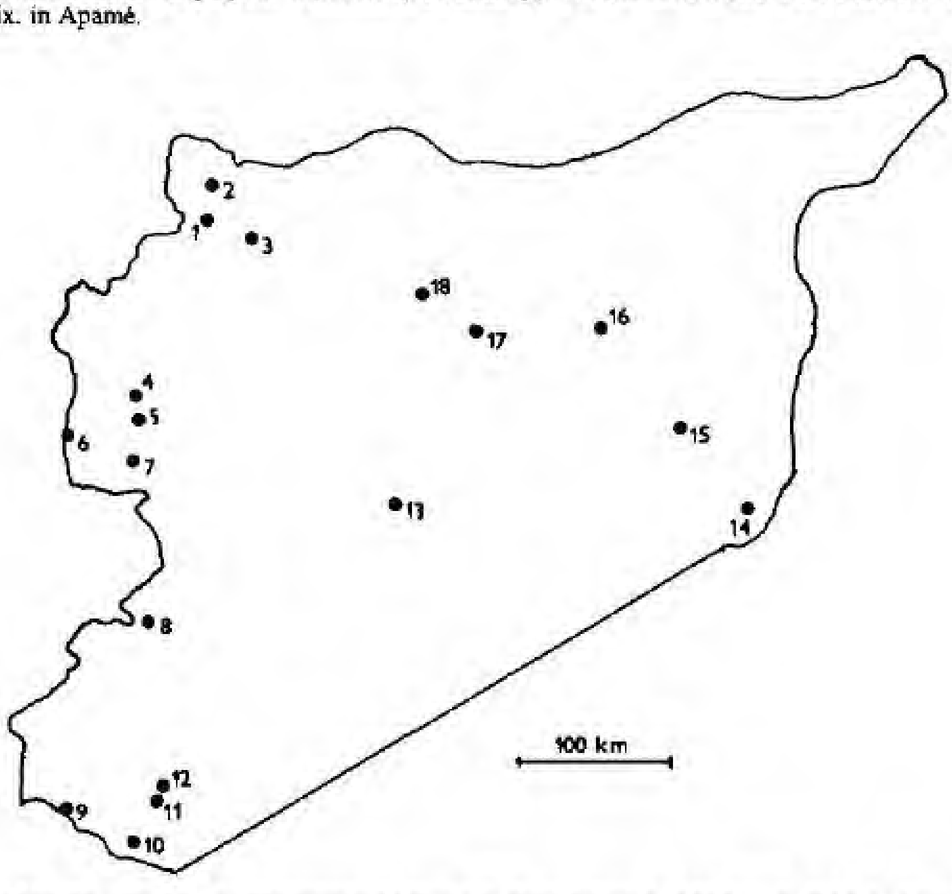

Fig. 1. Map of Syria, showing localities mentioned in the text. 1 – Qalaat Samaan, 2 – Afrin Suyn, 3 – Halab, 4 – Apamé, 5 – Musyaf, 6 – sea shore north of Tartous, 7 – Qalaat al-Hosn, 8 – Maalula, 9 – Tall Shebab, 10 – Bosra, 11 – Qanawat, 12 – Shabha, 13 – Tadmur, 14 – As Sayyal, 15 – Qalaat Rabbah, 16 – Zenobia, 17 – Russafa, 18 – Euphrates dam.

Palm dove *Streptopelia senegalensis* (Linnaeus): Several individuals were observed on 29.ix. in Halab, and on 4.x. at Shahba.

Barn owl *Tyto alba* (Scopoli): Individuals were seen on 29.x. in Apamé, and on 7.–8.x. at Russafa. Feathers of this owl were found also at Qalaat Rabbah (6.x.). Pellets were collected at Qalaat Rabbah (few) and at Russafa (many). In addition, a large sample of Subrecent prey remains was collected at Russafa. Their analysis will be presented elsewhere.

Little owl *Athene noctua* (Scopoli): Observed on 29.ix. in Apamé, on 6.x. at Zenobia, and on 7.–8.x. at Russafa. Samples of pellets were collected at Zenobia and at Russafa.

Nightjar *Caprimulgus europaeus* Linnaeus: An individual was seen flying in the evening of 4.x. over the desert at Tadmur.

Alpine swift *Apus melba* (Linnaeus): A flock was seen on 1.x. above Qalaat el-Hosn.

White-breasted kingfisher *Halcyon smyrnensis* (Linnaeus): An individual was observed on 6.x. at As Sayyal. This is the second observation of this species from Syria, the first one being from the 6.xi.1983 at Derra (Baumgart & Stephan 1986).

Kingfisher *Alcedo atthis* (Linnaeus): An individual was seen on 8.x. flying above water at the Euphrates dam.

Blue-cheeked bee-eater *Merops superciliosus* Linnaeus: A small flock was observed on 6.x. at As Sayyal.

Bee-eater *Merops apiaster* Linnaeus: Small flock was seen flying on 5.x. over desert at Tadmur.

Hoopoe *Upupa epops* Linnaeus: Individuals were seen on 3.x. at Tall Shebab, and on 5.x. at Tadmur.

Lesser short-toed lark *Calandrella rufescens* (Vieillot): Several individuals were seen on 6.x. at As Sayyal. This is the first fall record of this species in Syria.

Crested lark *Galerida cristata* (Linnaeus): Individuals were observed on 28.ix. south of Afrin, on 29.–30.ix. at Apamé, on 3.x. at Tall Shebab, and on 6.x. at As Sayyal.

Temminck's horned lark *Eremophila bilopha* (Temminck): Common in a ploughed desert east of Maalula (1.x.).

Crag martin *Ptyonoprogne rupestris* (Scopoli): Common in Maalula (1.x.).

Barn swallow *Hirundo rustica* Linnaeus: Individuals and small flocks were seen on 29.ix. in Halab, on 3.x. at Tall Shebab, on 5.x. in Tadmur, on 6.x. at As Sayyal, on 7.x. at Zenobia, and on 8.x. at Russafa.

Yellow wagtail *Motacilla flava* Linnaeus: An individual was seen on 4.x. at a small desert dam at Salim.

Grey wagtail *Motacilla cinerea* Tunstall: An individual was observed on 3.x. at a gorge creek at Tall Shebab.

White wagtail *Motacilla alba* Linnaeus: Individuals were observed on 7.x. at Zenobia, and on 8.x. at Russafa.

Black-capped bulbul *Pycnonotos xanthopygos* (Ehrenberg): Recorded on 3.x. at Tall Shebab.

White-throated robin *Irania gutturalis* (Guérin-Méneville): Individuals were observed on 3.x. at Tall Shebab, and later on the same day at Qanawat. This is first observation of this species in southern Syria, and in fall. All four previous observations were limited to April (Baumgart & Stephan 1994). In the nearby Jordan, White-throated Robins are scarce spring (iv.) and very scarce fall (vii.–viii.) migrants (Andrews 1995).

Black redstart *Phoenicurus ochruros* (Gmelin): An individual was seen on 4.x. at Salim.

White-fronted redstart *Phoenicurus phoenicurus* (Linnaeus): An individual was observed on 8.x. at Russafa.

Northern wheatear *Oenanthe oenanthe* (Linnaeus): Recorded on 3.x. at Tall Shebab.

Pied wheatear *Oenanthe pleschanka* (Lepechin): Observed on 1.–2.v. at Tadmur (PB).

Black-eared wheatear *Oenanthe hispanica* (Linnaeus): Observed on 8.x. at Russafa.

Mourning wheatear *Oenanthe lugens* (Liechtenstein): Common in deserts around Tadmur (5.x.).

Blue rock thrush *Monticola solitarius* (Linnaeus): Several individuals were seen on 1.x. on Qalaat el-Hosn.

Blackbird *Turdus merula* Linnaeus: An individual was observed on 3.x. in shrubs at Qanawat. This is the first record of blackbirds for the Doruz Mountains.

Stripe-backed prinia *Prinia gracilis* (Liechtenstein): Individuals were seen on 29.ix. in Apamé, and on 30.ix. in sparse shore vegetation Tartous.

Scrub warbler *Scotocerca inquieta* (Cretzschmar): An individual was observed on 6.x. at As Sayyal. Both two previous records of this species from Syria were limited to Anti-Lebanon Mountains (Baumgart & Stephan 1987, 1994).

Blackcap *Sylvia atricapilla* (Linnaeus): Recorded on 3.x. at Tall Shebab.

Spotted flycatcher *Muscicapa striata* (Pallas): Recorded on 29.ix. at Halab.

Great tit *Parus major* Linnaeus: An individual was seen on 28.ix. in a pine growth at Qalaat Samaan, and small flocks were observed on 30.ix. and 1.x. at Qalaat el-Hosn.

Great grey shrike *Lanius excubitor* Linnaeus: An individual was observed on 3.x. in the gorge at Tall Shebab. This is the first record of this species for Syria. This shrike is a common resident in adjacent parts of Jordan (Andrews 1995).

Black-billed magpie *Pica pica* (Linnaeus): An individual was seen on 6.x. at As Sayyal.

Crow *Corvus corone cornix* Linnaeus: Repeatedly seen in western Syria and around Euphrates river, particularly south of Afrin (28.ix.), at Halab (29.ix.), at Maalula (2.x.), at Tall Shebab (3.x.), and at As Sayyal (6.x.).

Northern raven *Corvus corax* Linnaeus: Recorded in small numbers on 5.x. at Tadmur and along the main road between Tadmur and Deir-ez-Zoor. I have not seen it south of Tadmur along the main road between Damascus and Tadmur on 4.x.

House sparrow *Passer domesticus* (Linnaeus): Commonly seen south of Afrin (28.ix.), in Halab (29.ix.), Apamé (29.iv. – PB, 29.–30.ix. – JM), Masyaf (30.ix.), Tartous (30.ix.), Qalaat el-Hosn (30.ix.), Maalula (1.–2.x.), Tall Shebab (3.x.), Bosra (3.x.), Shabha (4.x.), Tadmur (4.–5.x.), As Sayyal (6.x.), and Russafa (8.x.).

Rock sparrow *Petronia petronia* (Linnaeus): Flocks were observed on 1.–2.x. at Maalula.

Greenfinch *Carduelis chloris* (Linnaeus): Recorded on 28.ix. south of Afrin (in flocks of *Carduelis carduelis*), and on 30.ix. at Qalaat el-Hosn.

Goldfinch *Carduelis carduelis* (Linnaeus): Large flocks were observed on 28.ix. south of Afrin.

Linnet *Carduelis cannabina* (Linnaeus): A large flock was seen on 4.x. feeding on weed at a small desert dam near Salim. This is the first record of this species in central Syria. Previously, linnets were known from western Syrian and Jordan mountains only (Baumgart & Stephan 1987, 1994, Andrews 1995).

Black-headed bunting *Emberiza melanocephala* Scopoli: Two flocks with ca. 30 individuals each were observed on 29.iv. at Apamé (PB). No buntings were present at the same place on 29.–30.ix. (JM).

DISCUSSION

According to Baumgart & Stephan (1994), 217 species of birds were recorded from the territory of Syria so far. During my visit to Syria, two new species could be added to the list: little gull *Larus minutus*, and great grey shrike *Lanius excubitor*. This raises the total of the Syrian avifauna to 219 species. Nevertheless, this is apparently still an underestimate, because avifauna of the nearby Jordan counts 374 species (Andrews 1995).

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Acta Soc. Zool. Bohem. 60: 43–49, 1996
ISSN 0862-5247

Contribution to the feeding ecology of *Strix aluco* and *Bubo bubo* (Aves: Strigiformes) in southwestern Bulgaria

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Received December 15, 1995; accepted February 29, 1996
Published April 5, 1996

Abstract. In southwestern Bulgaria in rocky habitats of the Struma River valley and Rodopi Mts. were collected 4 and 2 small samples of tawny owl's and eagle owl's prey remnants, respectively. Abundance of identified prey species was analyzed and feeding ecology of the two owl species was characterized in comparison with published sources using the method of significant differences from the mean. From 390 prey items of tawny owl, 35 taxa was identified. Mammals markedly prevail (25 species, 53.6%), birds are uncommon (7.6%), slugs reach high percentages (24.6 %). High diversities of mammals (21 species, 70.4%) and birds (42 taxa, 24.4%) feature in two samples of eagle owl's prey remnants from the Struma valley. Our data on the food of eagle and tawny owls were compared with all the literary data available from Bulgaria and the blocks of diagnostic species with significant positive differences from the mean were provided. The food of eagle owl in Bulgaria shows high variability and diversity (H'>4), being dominated by species with greater body size and containing high percentage of birds. The finding of *Tadarida teniotis* remnants in tawny owl's pellets represents the third record of this bat species in Bulgaria.

Feeding ecology, *Strix alaco, Bubo bubo,* Bulgaria

INTRODUCTION

The study of food composition in owls may be fairly important not only in the field of owl ecology, but also in providing new insights into the structure of animal communities. In Bulgaria, studies of this kind have been conducted mainly by Simeonov and his colleagues (cf. Simeonov et al. 1990). The food of long-eared owl (*Asio otus*) was studied by Simeonov (1963, 1966), Simeonov & Petrov (1986), and Obuch (1989). Simeonov (1983a) analyzed the food of short-eared owl (*Asio flammeus*). The survey of the food composition of barn owl (*Tyto alba*) in Bulgaria was published by Simeonov (1978), and Simeonov et al. (1981). The food of little owl (*Athene noctua*) was reviewed by Simeonov (1983).

The food of eagle owl, *Bubo bubo* (Linnaeus, 1758), in Bulgaria was studied by Baumgart et al. (1973), Baumgart (1975), and Simeonov & Boev (1988), nesting and feeding ecology of tawny owl, *Strix aluco* Linnaeus, 1758, by Simeonov (1985). Studies of eagle owl's, tawny owl's and barn owl's prey remnants are useful also for research of distribution of small mammals, as showed for Balkans, for example, by Niethammer (1962), and Vohralík & Sofianidou (1992a). Along with the broader knowledge on the food of eagle owl and tawny owl from the Struma River valley, this paper provides also new data on the food of tawny owl from the Rodopi Mts.

MATERIAL AND METHODS

In eagle owl, samples of prey remnants were obtained from nests and their surroundings. In tawny owl, pellets were collected from diurnal resting places in rocks.

Sampling sites

Tawny owl

1. Simitli (dist. Blagoevgrad), south of the town on the left side of the Struma River, pellets scattered in two deep gullies, April 30, and May 1, 1985.
2. Kričim (dist. Plovdiv), rocks on the right side about 10 km up the mouth of the Vyča valley, pellets scattered over a large rocky slope, May 5, 1985.
3. Peruštica (dist. Plovdiv), andesite rocks, pellets in a rock gate, April 28, 1985
4. Laki (dist. Smoljan), limestone rocks on the right side of the valley below the town, owl's resting place in ivy, April 27, 1985.

Eagle owl

1. Rupite (dist. Blagoevgrad), rock outcrop on the left side of the Struma River near the mouth of the Strumešnica River, August 5, 1994.
2. Simitli (dist. Blagoevgrad), rocks south of the town on the left side of the Struma River, April 30, 1985.

Except for Rupite, all sites were sampled by the first author. Pellets were processed by 5% solution of sodium hydroxide and following types of prey remnants were determined: jaws (mammals and reptiles), humerus, metacarpus, tarsometatarsus and bills (birds), os ilium (anurans), heads (beetles) and rudimentary shells (slugs). Prey abundance estimates are minimum possible, i. e. counts of the most frequent type of remnant for a particular species. Tables 1–3 contain values of significant positive (+) or negative (–) differences from the sample mean according to the method of Obuch (1991) that were calculated using extreme values of the linear equation $x=1.2a_4+4$ and its multiples and were placed on the left side of each column. Tab. 1 compares our summarized data to the mean from all available Bulgarian samples including data of Simeonov (1985). In Tab. 3, only species with significant positive differences from the mean are showed in appropriate block arrangement. Index of diversity H' was calculated by the Shannon formula employing natural logarithms ($\log_e$).

While samples were collected at relatively low-altitude sites, hardly determinable voles from the subgenus *Microtus* were attributed to the species *Microtus epiroticus*. In southern Bulgaria, *M. arvalis*, morphologically nearly identical, has been found only in altitudes above 1000 m a. s. l. (cf. Vohralík & Sofianidou 1992a) and its presence in our samples seems thus unlikely. House mice are treated here as *Mus* sp., because both synanthropic *Mus domesticus* and exoanthropic *M. macedonicus* (= *M. abbotti*) could occur in the area of interest (Orsini et al. 1983).

RESULTS AND DISCUSSION

The food of tawny owl

Four small samples of pellets from the Struma River valley and the Rodopi Mts yielded 390 prey items belonging to 35 taxa in total (Tab. 1). Greatest diversity and abundance values were found in mammals (25 species, 53.6% dominance), birds (13 species, 7.9%) gave small numbers in our samples. In some samples, anurans (*Rana* cf. *dalmatina*), beetles (Coleoptera) and slugs (cf. Limacidae) occured in markedly higher abundances. Slugs accounted for as much as 1/4 of the prey amount.

Our samples were obtained from sites less disturbed by human activities and surrounded by extensive forest and rocky habitats. Samples of Simeonov (1985) encompass 19 sites (none of them from the Rodopi Mts) and came mostly from agricultural landscapes. This fact can account for higher dominance of species inhabiting rocks (+ *Myoxus glis*, *Nyctalus noctula*), forest habitats (+ *Apodemus flavicollis*, *Microtus subterraneus*) and for some local taxa (+ *Chionomys nivalis*, Scorpionoidaea) in our samples. In extensive forest tracts, tawny owl apparently preys more frequently on slugs (+ cf. Limacidae). Correspondingly high dominance values of slugs in the food of tawny owl were reported also from some mountains of Slovakia, e. g., from the Muránska Planina Mts (Obuch 1992). Samples of Simeonov (1985) showed markedly higher abundances of voles (*Microtus* sp.) and birds (+ Aves).

Tab. 1. Results of prey remnant analysis in tawny owl from southwestern Bulgaria

prey species \ site		Simitli	Kričim		Peruštica		Laki		Σ	%
Talpa europaea			1		5				6	1.5
Sorex araneus			1		2			2–	3	0.8
Sorex minutus			1		1		1		3	0.8
Neomys anomalus							1		1	0.3
Crocidura leucodon		1			1		1	1–	3	0.8
Crocidura suaveolens					2				2	0.5
Myotis mystacinus							1		1	0.3
Myotis blythi					1		1		2	0.5
Eptesicus serotinus							1		1	0.3
Nyctalus noctula				1–		1+	11	1+	11	2.8
Plecotus austriacus					1				1	0.3
Miniopterus schreibersi							1		1	0.3
Tadarida teniotis							1		1	0.3
Myoxus glis			6		13		13	2+	32	8.2
Dryomys nitedula		1			1		1		3	0.8
Muscardinus avellanarius					6		1		7	1.8
Mus sp.					1				1	0.3
Apodemus flavicollis	1–	2	17	1+	60	1–	10	1+	89	22.8
Apodemus sylvaticus							2		2	0.5
Apodemus mystacinus		3							3	0.8
Rattus rattus		1			1		1		3	0.8
Clethrionomys glareolus					1		2	1–	3	0.8
Microtus subterraneus			3		10		1	2+	14	3.6
Microtus epiroticus					1			5–	1	0.3
Chionomys nivalis			1		8		6	2+	15	3.8
Mammalia, 25 species	1–	8	30		115		56	1–	209	53.6
Hirundo rustica					2		1		3	0.8
Delichon urbica					3				3	0.8
Phylloscopus collybita							1		1	0.3
Erithacus rubecula					1		1		2	0.5
Turdus merula							1		1	0.3
Turdus philomelos		1			3				4	1.0
Parus major		1			2				3	0.8
Parus ceruleus					3		1		4	1.0
Parus cristatus					1				1	0.3
Fringila coelebs		1			2				3	0.8
Carduelis chloris					1				1	0.3
Coccothraustes coccothraustes					2				2	0.5
Passer domesticus					2			1–	2	0.5
Passeriformes sp.					1				1	0.3
Aves, 13 species		3		1+	23		5	1–	31	7.9
Rana cf. dalmatina				2–	1	1+	24	2+	25	6.4
Lacerta viridis							1		1	0.3
Ablepharus kitaibeli							1		1	0.3
Lacerta sp.			1				2		3	0.8
Coleoptera sp.			1	1+	15		3	1–	19	4.9
Scorpionoidea sp.					5			1+	5	1.5
cf. Limacidae sp.	1+	28	16	1–	22		30	3+	96	24.6
Sample totals		39	48		181		122		390	
Diversity H'		1.61	2.33		3.62		3.45		3.68	

Tab 2 Results of prey remnant analysis in eagle owl from southwestern Bulgaria

prey species \ site	Rupite		Smith		Σ	%	prey species \ site	Rupite		Smith		Σ	%
Erinaceus concolor		7		7	14	4 5	*Larus ridibundus*				1	1	0 3
Talpa europaea		2			2	0 6	*Columba livia*				2	2	0 6
Neomys anomalus	1+	23	1–		23	7 4	*Columba oenas*		1			1	0 3
Crocidura leucodon		13	1–		13	4 2	*Streptopelia turtur*	1–		1+	8	8	2 6
Crocidura suaveolens	1+	32	2–		32	10 3	*Cuculus canorus*				2	2	0 6
Eptesicus serotinus				1	1	0 3	*Asio otus*				1	1	0 3
Nyctalus noctula		1			1	0 3	*Otus scops*				1	1	0 3
Lepus europaeus		1		3	4	1 3	*Athene noctua*				1	1	0 3
Myoxus glis				4	4	1 3	*Strix aluco*		1			1	0 3
Dryomys nitedula		1		1	2	0 6	*Coracias garrulus*				1	1	0 3
Mus sp		22	1		22	7 1	*Upupa epops*				1	1	0 3
Micromys minutus	1+	6			6	1 9	*Galerida cristata*				1	1	0 3
Apodemus flavicollis		7		3	10	3 2	*Hirundo rustica*		1			1	0 3
Apodemus sylvaticus		8		2	10	3 2	*Motacilla alba*				1	1	0 3
Apodemus mystacinus				6	6	1 9	*Lanius collurio*	1–		1+	8	8	2 6
Apodemus agrarius		7		1	8	2 6	*Regulus sp*				1	1	0 3
Rattus rattus		1		1	2	0 6	*Erithacus rubecula*				2	2	0 6
Arvicola terrestris		10			10	3 2	*Turdus merula*				1	1	0 3
Microtus epiroticus		45	2–	2	47	15 1	*Turdus pilaris*				1	1	0 3
domestic cat	1+	1			1	0 3	*Turdus philomelos*				4	4	1 3
domestic pig		1			1	0 3	*Turdus viscivorus*				2	2	0 6
Mammalia, 21 species	1+	188	1–	31	219	70 4	*Troglodytes troglodytes*				1	1	0 3
Tachybaptus ruficollis		1		1	2	0 6	*Passer domesticus*		1			1	0 3
Ixobrychus minutus				1	1	0 3	*Sturnus vulgaris*		1			1	0 3
Anas platyrhynchos				1	1	0 3	*Oriolus oriolus*				1	1	0 3
Anas crecca		1			1	0 3	*Garrulus glandarius*				1	1	0 3
Anatidae sp				4	4	1 3	*Corvus corone*				1	1	0 3
Falco tinnunculus				1	1	0 3	Aves sp				3	3	1 0
Falco cf neumanni				1	1	0 3	Aves, 42 species	2–	11	1+	65	76	24 4
Alectoris graeca		1		4	5	1 6	*Pelobates syriacus*	1–		1+	9	9	2 9
Perdix perdix				1	1	0 3	Amphibia sp		1			1	0 3
Porzana porzana				1	1	0 3	Reptilia sp		4			4	1 3
Gallinula chloropus		1		1	2	0 6	Pisces sp		1			1	0 3
Fulica atra		1			1	0 3	Coleoptera sp				1	1	0 3
Vanellus vanellus				1	1	0 3	Sample totals		205		106	311	
Scolopax rusticola		1		2	3	1 0	Diversity H'		3 58		4 88	4 54	

The food of eagle owl

Our material consisting of two samples from the Struma River valley (Tab 2) exhibits high abundances of mammals (21 species, 70 4%) and birds (42 taxa, 24 4%) Sample from Rupite is dominated by mammals, but in the sample from Smith, birds are twice as abundant as mammals and *Pelobates syriacus* is abundant as well These samples are thus considerably different Table 3 compares our material to this of Baumgart et al (1973) from the Iskar River valley, Baumgart (1975) from NE Bulgaria and Simeonov & Boev (1988) from whole Bulgaria

When comparing with other Bulgarian samples, the sample from Rupite differs in extraordinary high dominance of some shrews (+ *Crocidura suaveolens, C leucodon, Neomys anomalus*). Shrews are only infrequently present not only in the food of eagle owl, but also of other owl

Tab 3 Food of eagle owl in Bulgaria comparative overview of diagnostic species from our data (Struma River valley) to those of Baumgart et al (1973) (Iskar River valley), Baumgart (1975) (Dobrudža plateau), and Simeonov & Boev (1988) (whole Bulgaria)

Prey species	region								Σ	[%]
	Struma v		Iskar v		Dobrudža		Bulgaria			
number of samples	2		6		10		18		36	
Crocidura suaveolens	3+	32	1–		2–		2–		32	0 96
Crocidura leucodon	2+	13					1–		13	0 39
Neomys anomalus	2+	23	1–		1–		2–		23	0 69
Mus sp	2+	22	1–		1–		1–	1	23	0 69
Microtus epiroticus	2+	47	2–	9	1+	49	1–	38	143	4 27
Apodemus flavicollis	1+	10	2–		2–		1+	33	43	1 29
Apodemus mystacinus	1+	6							6	0 18
Apodemus agrarius	1+	8							8	0 24
Micromys minutus	1+	6				1			7	0 21
Lanius collurio	1+	8		2		4	1–		14	0 42
Pelobates syriacus	1+	9							9	0 27
Erinaceus concolor	1–	14	1+	203	1–	42	1–	139	398	11 89
Lepus europaeus	1–	4	1+	56	1–	17		61	138	4 12
Myoxus glis		4	1+	44	1–	10		28	86	2 57
Apodemus sylvaticus		10	1+	52	1–	10	1–	34	106	3 17
Alectoris graeca		5	1+	23	2–			18	46	1 37
Apus melba			1+	16	1–		1–		16	0 48
Turdus merula		1	1+	11		3		5	20	0 60
Anura sp	1–	1	2+	43		15	3–		59	1 76
Mesocricetus newtoni	1–		3–		2+	81	3–	1	82	2 45
Spermophilus citellus	2–		1–	5	1+	34	1+	52	91	2 72
Coturnix coturnix	1–		2–		1+	36		27	63	1 88
Crex crex				1	1+	9	1–		10	0 30
Rallus aquaticus					1+	7			7	0 21
Gallinula chloropus		2	1–	2	1+	19	1–	7	30	0 90
Fulica atra		1			1+	13		4	18	0 54
Columba livia		2	2–	1	1+	33		17	53	1 58
Streptopelia decaocto					1+	6			6	0 18
Apus apus			1–		1+	16		7	23	0 69
Upupa epops		1			1+	10		2	13	0 39
Alauda arvensis					1+	6			6	0 18
Corvus monedula	1–			11	1+	44	1–	10	65	1 94
Talpa europaea		2	2–	1		11	1+	42	56	1 67
Sciurus vulgaris				7	1–	2	1+	19	28	0 84
Rattus norvegicus	3–		1–	29		62	1+	116	207	6 19
Rattus rattus		2	1–		1–		1+	18	20	0 60
Arvicola terrestris		10	2–	8	1–	26	1+	96	140	4 18
Mustela nivalis						1	1+	10	11	0 33
Phasianus colchicus			1–		1–		1+	21	21	0 63
domestic fowl			1–	2		13	1+	25	40	1 20
Columba palumbus			1–		1–	2	1+	30	32	0 96
Pica pica			1–			6	1+	16	22	0 66
Rana ridibunda	1–		2–		2–		1+	58	58	1 73
Rana sp					1–		1+	18	18	0 54
Anguis fragilis							1+	10	10	0 30
Lacerta viridis							1+	11	11	0 33
Decapoda sp				1			1+	12	13	0 39
Coleoptera sp	2–	1		28		35	1+	79	143	4 27
Sample totals		311		733		854		1448	3346	
Diversity H'		4 54		4 13		5 12		4 88		

species with the exception of barn owl (Obuch 1992a) occupying also rocks in southern Europe and thus making an admixture of its pellets to pellets of eagle owl in Rupite sample possible. Our material exhibits significantly higher dominance of the three mice from the genus *Apodemus* (+ *A. flavicollis, A. agrarius, A. mystacinus*). All these species are difficult to distinguish and it seems probable that Baumgart et al. (1973) and Baumgart (1975) assigned them to *A. sylvaticus*. Differences in determination accuracy might be seen also in anurans: we have determined the species *Pelobates syriacus*, but in papers of Baumgart, only anurans (Anura) were reported. Simeonov & Boev (1988) have recorded frogs (*Rana ridibunda, Rana* sp.).

In the material from the Iskar River valley (Baumgart et al. 1973), some mammals (+ *Erinaceus concolor, Lepus europaeus, Myoxus glis*) and birds (+ *Alectoris graeca, Apus melba, Turdus merula*) were more abundant, characterizing drier environments with shrubs and large rocks. Elevated dominance of steppe mammals (+ *Mesocricetus newtoni, Spermophilus citellus*), birds (+ *Crex crex, Coturnix coturnix, Upupa epops, Alauda arvensis*) as well as many waterfowl species (probably hunted near the Black Sea coast) is distinctive to the material from the Dobrudža plateau and wider surroundings. In summarized data from the whole Bulgaria (Simeonov & Boev 1988) there appear many species with markedly higher dominance as a consequence of greater number of samples covering broader range of habitats. A part of these species is more closely associated with human activities (+ *Rattus norvegicus, R. rattus*, domestic fowl, *Phasianus colchicus*).

The food of eagle owl in Bulgaria may be characterized as very variable with high prey species diversity (H'>4). Considerable differences appear not only between particular samples, but also between regions. As compared to the data from central Europe (Obuch unpubl.), eagle owl in Bulgaria hunts prey with greater body size and also greater percentage of birds. It might be due to the fact that non-forest habitats in Bulgaria are native to the greater extent and can provide eagle owl with near-natural food supply.

Faunistic comments

Among the six samples analyzed, two show abundances of mammals sufficient to evaluate some aspects of small mammal synusia. The sample from Peruščica (115 items of tawny owl's prey) is typical for forested areas with presence of shrews from the genus *Sorex*, higher percentage of dormice and presence of *Microtus subterraneus*; presence of *Chionomys nivalis* documents the incidence of screes close to the site. On the other hand, the site Rupite (188 items of eagle owl's prey) may be regarded as typical sample of warm lowland landscape characterized by the high percentage of the two *Crocidura* species and by the absence of forest species.

Among faunistic records should be mentioned the presence of *Apodemus mystacinus* in two samples from Simitli. After Markov (1974), *A. mystacinus* occurs in Bulgaria only in the Struma valley (north to Kjustendil) and in southernmost Bulgarian part of the Mesta valley (vicinity of Goce Delčev). Another remarkable finding is *Apodemus agrarius* from Simitli and Ploski whose findings south of the Stara Planina Mts are scarce (Vohralík & Sofianidou 1992). In the case of bat remnants, mostly more common species are involved, but very important is the finding of *Tadarida teniotis* near Laki which represents the third record for Bulgaria and second for the Rodopi Mts (Kalčev & Beškov 1963, Pandurska 1992).

Acknowledgement

The study was supported by the grant GA ČR 204/93/0531.

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Acta Soc. Zool. Bohem. 60: 51–56, 1996
ISSN 0862-5247

Contribution to roost ecology of *Myotis brandti* (Mammalia: Chiroptera) in the Czech Republic and Slovakia

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Received February 23, 1996; accepted February 29, 1996
Published April 5, 1996

Abstract. The first records of four nursery colonies of *Myotis brandti* in the area of Moravia (the Czech Republic) and Slovakia are given. Nursery colonies roosted in narrow crevices beneath roofing of buildings, located in the vicinity of woodlands and watersides. The record of the mixed nursery colony of *M. brandti* and *M. mystacinus* is the first evidence of common mass roosting of these species in summer.

Nursery colony, roost preference, habitat preference, *Myotis brandti*

INTRODUCTION

Myotis brandti (Eversmann, 1845) is a palearctic species whose range extends from England, S-Scotland and NE-France in the west to Kamchatka and Sakhalin in the east (Hackethal 1987). Its northerly range extends to Sweden, Finland, Estonia and N-Russia, and in the south *Myotis brandti* reaches Italy, Switzerland, Bulgaria, S-Russia, N-Kazakhstan, S-Altai, N-Mongolia and Manchuria. The south and north borders of its distribution are limited to 42° N, and 65° N respectively (Roer 1975, Strelkov & Buntova 1982). *M. brandti* occurs together with *M. mystacinus* (Kuhl, 1819) throughout most of Central Europe. The ratio of the number of records of *M. brandti* to the number of records of *M. mystacinus* increases from the west to the east, and from the south to the north (Strelkov & Buntova 1982). *M. brandti* is considered to be an original Central European form, whereas *M. mystacinus* settled on the European continent during the post-glacial period (Ruprecht 1974).

M. brandti is a typical woodland boreal species (Strelkov 1983, Taake 1984) that prefers lowlands with an abundance of water bodies such as the areas in N-Europe (e. g. Denmark, Germany, Poland, Finland, N-Russia etc.) (Ruprecht 1974, Strelkov & Buntova 1982, Taake 1984, Lehmann 1984). In Central Europe, nursery colonies of *M. brandti* also occur most frequently in lowlands, although in Switzerland a nursery colony was found at 1270 m above sea level (Roer 1975, Schober & Grimmberger 1989). They are frequently found in the lofts of buildings, particularly those of timber construction (e. g. log cabins, barns, sheds) situated in secluded places, or in the vicinity of forests (Hanák 1971, Schmidt 1979, Boye 1993). They are also commonly in settlements, but not as frequently as colonies of *M. mystacinus* (Hanák 1971, Roer 1975, Hackethal 1987). Crevices under roof covering or gaps between timber beams are the most common roost shelters of Brandt's bat colonies (Hůrka 1973, Schmidt 1979, Boye 1993). Unlike other woodland bat species *M. brandti* does not usually occupy tree holes, however its summer colonies in bat or bird boxes are known (Heise 1982, Hackethal 1987, Schober & Grimmberger 1989).

The distribution of *Myotis brandti* in the area of the Czech Republic and Slovakia is relatively little known. Hanák (1971) presents only 25 localities from Bohemia and Moravia as a whole. Nursery colonies were discovered at two sites, in Bychory near Kolín (central Bohemia, 210 m a. s. l.) and in Žihobce near Klatovy (SW-Bohemia, 470 m a. s. l.). A further colony was recorded in Poteply near Kladno (central Bohemia) (Horáček, in verb.). No nursery colonies of *M. brandti* have been recorded in Moravia or Slovakia.

This contribution informs about unpublished finds of four nursery colonies of *M. brandti* and comprises notes about roost and habitat preference of this species.

METHODS

In 1970–1993 an occasional investigation was carried out and reported finds are to be considered as accidental ones. Certain indications of a nursery colony evidence in the building lofts were the finds of unfledged juvenile mummies and the presence of a considerable number of small droppings. After discovery of a colony some individuals were removed from shelters by using long tweezers. Visual inspections were supported by netting bats inside the loft spaces, or outside in front of emergence slots. Most bats caught were identified to species, sexed, aged, measured, banded and released. Only a part of samples was used as proof and is deposited in the collection of the Silesian Museum in Opava (N-Moravia).

RESULTS

A review of own finds of nursery colonies of *Myotis brandti* in the Czech Republic and Slovakia

(1) **6071***): Leskovec nad Moravicí, d. Bruntál (N-Moravia), 500 m a. s. l.

In an abandoned old house near Heroldův Mlýn on the right bank of the Moravice River (about 100 m from the flow) six unfledged juvenile mummies of *Myotis brandti/mystacinus* were found in September 1987 on the stairs to the loft. All six young still had milk teeth, therefore exact species determination was not possible. In the loft a heap of small droppings was found, providing evidence of a traditional shelter of the nursery colony. During a roof inspection on 19 June 1988 about 10 disturbed individuals of a small bat species flew out from under the roofing and into the nearby forest. Unfortunately, in spring 1989 the roof had been destroyed, but on 3 June 1989 in the neighbouring abandoned house (former gamekeeper's lodge) about 100 m up the river, one adult female of *Myotis brandti* was found between roof timber beams. Another adult female of this species was discovered in the same loft the following day. Nevertheless, a considerable number of droppings indicating evidence of a nursery colony was not found. In the course of the next visit on 8 July 1989 a large colony of *M. brandti* consisting of females and unfledged young was found in the narrow crevice between roofing tiles (eternit) and roofing timber boards at a chimney wall. About 30 disturbed individuals flew away, the remainig ones, including unfledged babies, crept into inaccesible spaces under roofing. But we managed to catch six juveniles (4 males, 2 females). Before sunset we put a 9 m mist net across the loft space. 20 adult females were netted although most of the nursery colony emerged straight out through leaks in the roof. During the night some individuals were flying in the loft space, but they avoided the mist net with the exception of a few netted specimens. On the basis of a rough estimate of the number of bats in the roost shelter at the time of discovery, and the number of emerging bats after sunset, the total number of the nursery colony was established at about 100 individuals including unfledged young. The number of adult individuals was 50 at least. In view of the fact that no adult males or subadult bats were caught and no other species were found, it can be concluded that this was a large, single-species nursery colony consisting of adult females and

*) the code of the square of the Czech mapping grid

unfledged juveniles. All trapped females had been transported to Leskovec village where they were measured and immediately after banding, released. Two bats released at 1.00 a. m. CET (Central European time) were recaptured two hours later in the same loft (2 km flight). Unfortunately, this locality was also destroyed during autumn 1989.

The side of both roofs in the direction of the forest was constructed from slate tiles while the opposite side opening to the river was formed from eternit tiles. Before disturbing bats roosted under eternit roof covering. The locality was situated on woodlands at the valley of Moravice river, in the flooded area of the future water reservoir Slezská Harta (the Nízký Jeseník Mts.). The forest had reached almost to meandering river, but at the time of our visits all trees in a flooded belt had already been felled.

(2) **6074**: Kobeřice, d. Opava (N-Moravia), 290 m a. s. l.

In the continous slot under a tin roof of a farm building in the pheasantry near Kobeřice village (1.5 km) a mixed nursery colony of *Myotis brandti* and *M. mystacinus* was found. On 14 July 1971 two lactating females of *M. brandti*,one lactating female of *M. mystacinus* and four unidentified unfledged young were removed from a roost shelter. The number of this colony was estimated to 20 adult females. Isolated groups of roosting bats were not observed. On 30 July 1973 the mist net was exposed from outside in the vicinity of emergence cracks under roof covering close to the roof edge. Three adult females of *M. brandti* and three adult females of *M. mystacinus* were netted. Every females were pregnant with one embryo. In total, 39 bats were seen to fly out from the 2–3 m section of the slot under the roof. The colony was estimated to comprise 50 individuals. Following roof reconstruction (tin roofing was exchanged for baked clay tiles) no further bats have been found.

This locality is situated at the agricultural landscape of the Hlučinská pahorkatina hills with areas of secondary mixed woods. The building with a former colony stands in one of them. The nearest stream flows along the edge of the wood, at a distance of 300 m from the building.

(3) **6075**: Šilheřovice, d. Opava (N-Moravia), 230 m a.s.l.

During the inspection of the loft of a castle being located inside the park at the edge of Šilheřovice village, one lactating female of *Myotis brandti* was found on 21 June 1989 in the crack between roof timber boards. On 16 July 1990 seven clustering individuals of *M. brandti* were found behind a beam in the narrow crevices between timber boards and slate tiles. It might be only a part of the nursery colony including juveniles. One subadult female and three young were removed from shelter. One of these juveniles was fledged. A further visit to the castle loft on 2 July 1991 gave finds of three adult females, two of them were evidently pregnant. On 11 July 1992 a large nursery colony of females with juveniles was discovered in the narrow crevice between the oblique beam and roof timber boards. In the 1 m section of this crevice about 30 roosting individuals of *M. brandti* were estimated, three of them were removed (1 subadult and 2 juvenile females). On 5 June 1993 only four individuals occupied the previous year's shelter, but in a different place in the loft about 20 individuals of *M. brandti* were discovered between the oblique beam and the brick wall dividing the loft space. Most of them were adults and no babies were observed.

The landscape, where the castle park is situated, is located at the east edge of the Hlučinská pahorkatina hills. At a distance of 1 km from the park the unbroken Černý les wood spreads. There are three small water pools inside the castle park or at its edge. The park extends in the vicinity of a valley terrace of Odra river. This river with large ponds on both banks is at a distance of about 3.5 km from the castle.

(4) **7279**: Turček, d. Martin (central Slovakia), 820 m a. s. l.

On 24 June 1979 a large summer colony of *Myotis brandti* was found in the loft of the hunting lodge at the wood edge. Bat droppings and mummies indicated that it was a traditional roosting site of a nursery colony. The bats hid between timber beams, and no young were observed. About 120 bats were censused during their evening emergence from three gables, always from the small cracks under a roof ridge. The net was put in front of one gable close to the roof ridge and 29 females of *M. brandti* were netted. On 28 June 1979 one net was exposed at a distance of 10 m from the building and only one female and one subadult male of *M. brandti* were netted. No netted females were nursing this year. In total, 6 pregnant, 2 subadult females and 1 subadult male have been put in the collection of Silesian Museum.

The locality is situated in the Krámska dolina valley which spreads in a mountain wooded landscape of the Kremnické vrchy Mts. The mountain stream flows through the valley.

DISCUSSION

The discovery of three nursery colonies of *M. brandti* is the first evidence in the area of Moravia up to the present, similar to the colony in the Krámska dolina valley in Slovakia. Particularly, inaccesible shelters have resulted in sporadic reports of *M. brandti*. Netting in different areas of the Czech Republic and Slovakia showed that *M. brandti* cannot be as rare a species as previously thought. Former trapping of lactating females established the reproduction of this species both in Moravia and Slovakia (Danko & Mihók 1988, Gaisler et al. 1989). Confusion with *M. mystacinus* (sibling species) may be a further cause of limited information about nursery colonies of *M. brandti*. *M. brandti* was only identified as a separate species in 1970 and a lot of the earlier Brandt's bat discoveries were reported untill specimens deposited in museums had been reidentified. In this way, the first two summer colonies in Bohemia were rediscovered (Hanák 1971, Hůrka 1973).

The number of females constituting colonies of *M. brandti* ranges from 20 to 60 individuals (Schober & Grimmberger 1989). The Moravian and Slovakian discoveries suggest that the number of individuals in the nursery colonies in the mountain woodlands (Nízký Jeseník Mts., Kremnické vrchy Mts.) is higher than those in the agricultural landscape at the lower altitudes (Hlučínská pahorkatina hills). The preference for large areas of woodland may be the reason for *M. brandti* forming nursery colonies with higher numbers of individuals in middle and high altitudes than those in exploited lowlands with a lack of large forests. Likewise there are large summer colonies in woodlands of Westphalia. Vierhaus (1994) reports up to 350 females in one nursery colony under study. *M. brandti* shows a strong preference for woodlands and forms nursery colonies with higher numbers of individuals than sympatric *M. mystacinus*. Infrequent contact with man also appears to be a contributary factor in the high numbers of individuals within nursery colonies in woodlands (s. i.).

The piles of old droppings at both roosting sites situated at higher altitudes indicate a relatively persistence of the nursery colonies and also indicate their loyalty to these localities. However, the relocation of the nursery colony following the destruction of the original roosting site (Slezská Harta) to the nearest appropriate building is an indication of the adaptability of *M. brandti*. Repeated netting of two females in the same loft did not reveal any stress related symptons such as surpression of maternal instincts. Necessity to suckle babies probably motivated their return to the roost during the night. The choice of similar shelters indicates a strong preference for crevices and this is the case for all nursery colonies in the Czech Republic and Slovakia. The narrow cracks between roof timber boards and roof covering close to chimney

walls are the most frequent and typical shelters in buildings. The change of the nursing colony roost in Šilheřovice castle loft may be connected with the moving of females immediately before parturition (cf. Hůrka 1973). Similarly, direct disturbance can also result in the movement of bats. Disturbed bats, including unfledged juveniles, were observed crawling into deep inaccessible crevices or to disperse under the roof covering.

According to the presence of young and pregnant females during inspections, birth date may be estimated. No juveniles were found before 6 June. This corresponds with the data of Hůrka (1989) who found that the first births commenced at the end of the first ten-day period of June. Births begin earlier in the lowland colonies than those in highlands with a harsh climate. In the large Brandt's summer colony in the Kremnické vrchy Mts. no juveniles were found in the last ten-day period of June. The last pregnant females were found on 2 July in Šilheřovice. This corresponds with the contention that births continue till the middle of July (Schober & Grimmberger 1989). The date of parturition is probably influenced not only by the elevation of localities but also by the type of weather in a given year. It is possible that in adverse climatic conditions (especially during early summer) births start later and finish earlier whilst during favourable conditions females start to give birth earlier and the birth period lasts for a longer time (Rydell 1989, Ransome & McOwat 1994).

In the majority of cases *M. brandti* forms single-species summer colonies although it has been recorded together with *Pipistrellus nathusii* in bat or bird boxes (Heise 1982). A mutual affinity of these species was also observed in the castle loft in Šilheřovice. Although a nursing female of *P. nathusii* with its unfledged suckling was found in a different roosting place within the same loft it roosted in the same type of shelter. Both bat species seem to prefer similar roosts during the summer. However, mixed roosting in the same crevice of a shelter was not observed. Both species also prefer similar habitats. They occur in woodlands or parks with an abundance of water bodies (Schober & Grimmberger 1989).

The discovery of a mixed nursery colony of *M. brandti* and *M. mystacinus* in Kobeřice is the first of its kind, although mixed occurrences in hibernacula are usual (Roer 1975). Heise (1982) highlights the fact that in the summer habitats of *M. brandti*, *M. mystacinus* does not appear at all. However, nettings in some foraging areas indicated the common presence of both species in the same locality (Řehák, unpubl.) and thus excluded their ecological isolation during summer. Neverthless, the occurrence of both species in a mixed summer shelter is scarce. Bárta (1976) found one male of *M. brandti* together with one male of *M. mystacinus* in the crevice between timber beams of a log cabin close to the gamekeeper's lodge near Klatné (central Slovakia). The discovery of a mixed colony established not only identical roost preference but is also further evidence that *M. brandti* and *M. mystacinus* cannot be different geographical forms of one and the same species (Hanák 1971).

In accordance with the literary data, buildings with nursery colonies of *M. brandti* were located in woodlands, at the edge of the woods, or in the immediate vicinity. Taake (1984) reported that the occurrence of *M. brandti* was three times more frequent than that of *M. mystacinus* in woodlands of Westphalia. *M. brandti* also showed a preference for aquatic biotopes. With the exception of the colony in Šilheřovice, all the others occured close to flowing water although *M. brandti* should prefer stagnant water unlike *M. mystacinus* (Taake 1984).

In the Czech Republic and Slovakia where a diversity of landscapes is typical, a preference for lowlands with an abundance of lakes was not confirmed, unlike in N-Europe (Ruprecht 1974, Roer 1975, Strelkov & Buntova 1982, Lehmann 1984). On the contrary, the records from the Tatra Mts. at 1100 m above see level (Mošanský & Gaisler 1965) or from foothills of the Šumava Mts. (Hanák et al. 1995) show that elevation does not markedly influence the occur-

rence of *M brandti* The roost altitudes of all registered nursery colonies of *M brandti* in the Czech Republic and Slovakia range from 210 to 820 m above see level The character of the landscape appears to be a more important influencing factor than climatic conditions associated with elevation. The vicinity of woods and water seems to be a deciding factor in the choise of roosts

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Acta Soc. Zool. Bohem. 60: 57–62, 1996
ISSN 0862-5247

Contrahent muscles and their development in the hand of *Monodelphis domestica* (Mammalia: Marsupialia)

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Received September 22, 1995, accepted October 5, 1995
Published April 5, 1996

Abstract. A laboratory marsupial *Monodelphis domestica* was used in this study to complete previous comparative anatomical studies of mammalian contrahentes muscles. The contrahent muscle layer is generally characterized as a developmentally old structure in mammals. It is found in reduced and transformed form in different ordes. In *Monodelphis domestica* this layer was found to be formed in the whole extent of the palm splitting distaly into 4 muscles inserting on the 1st, 2nd, 4th, 5th fingres. During ontogenetic development of the majority of mammalian species, the reduction and disappearance of individual portions of the contrahentes layer occures. No such process was observed in the ontogeny of the contrahent muscle layer of *Monodelphis*. It supports the idea, that the extent of the layer of mm. contrahentes in *Monodelphis* proves the phylogenetically ancient pattern.

Musculi contrahentes, ontogeny of muscle layers of autopodium, pattern of contrahent muscle layer, mm. flexores breves profundi, ramus palmaris profundus nervi ulnaris, *Monodelphis domestica*

INTRODUCTION

This paper follows the previous studies of authors dealing with the development of muscle layer of mammalian autopodium. Trnková & Dylevský (1969, 1971, 1972, 1984), Dylevský & Trnková (1969, 1984), Trnková (1972, 1973, 1974). On the base succesive summarizing of informations about these structures we would like to help to understanding the development of the muscle layers in the phylogeny of mammalian hand regarding to eventual functional adaptations of individual groups of mammals. Our attention was especially engaged by a considerable heterogeny of the shape and the extent of the contrahent muscle layer. This structure is determined by its position in the palm and by its relation to the course of the deep palmar branch of ulnar nerve.

The literary data show that the number and the pattern of mm. contrahentes are different in different species of mammals. In some cases this layer is not described at all. (Dobson 1882, Leche 1900, Ribbing 1909, Forster 1916, Reed 1951, Haines 1955, Trnková 1972, 1973.)

This study demonstrates the contrahent muscle layer in the species *Monodelphis domestica* (Wagner, 1842) as a representant of marsupials with respect to the special position of this order in phylogenetic zoological system.

MATERIAL AND METHODS

The anatomical pattern and number of the contrahent muscles was studied in microdissected hands of four adult *Monodelphis domestica*. The forearms from 16 foetuses from the 1st to the 7th postnatal day (regarding the gestation only 11 days) were routinelly embeded in parafin. The serial sections were stained with Weigert's haematoxilin and eosin and used for study of the ontogeny of contrahent muscle layer.

RESULTS

Microdissections of the limb of adult *Monodelphis domestica* showed that the contrahent muscle layer was situated below the tendons of m. flexor digitorum longus joined with mm. lumbricales. The layer was separated from the deeper mm. flexores breves profundi by the course of a deep branch of the ulnar nerve. The muscle fibres originated on the palmar side of carpus and also from the fibrous raphe placed in the axis of the third finger. The distal margin of the layer was devided into four splits going to the 1st, 2nd, 4th and 5th fingers and inserted on the capsules of metacarpophalangeal joints and on the bases of the first phalanx from the side adjacent to the third finger. These splits represented mm. contrahentes digiti I., II., IV. et V. (Fig. 1). It was possible to distinguish a part of layer situated more superficially and going mostly to the first and to the fifth fingers (Fig. 2) and the deeper narrow part going to the second and the fourth fingers (Fig. 3). The fibrous raphe situated in the central axis of the palm was shared for both of these parts of the contrahent muscle layer.

The homogeneous blasteina of the contrahent muscle layer was found between the tendons of long flexors and deep palmar branch of n. ulnaris at the 1st postnatal day (Fig. 4). The studied layer exhibited during the further development only changes of its inner structure.

The seventh day of postnatal develoment the raphe laying in the axis of the 3rd metacarpal could be observed in the distal part of the palm. The fibres of the superficial part of the studied layer went obliguely from the raphe to the first and the fifth fingers, the fibres of the deeper part passed from the raphe to the second and fourth fingers (Fig. 5).

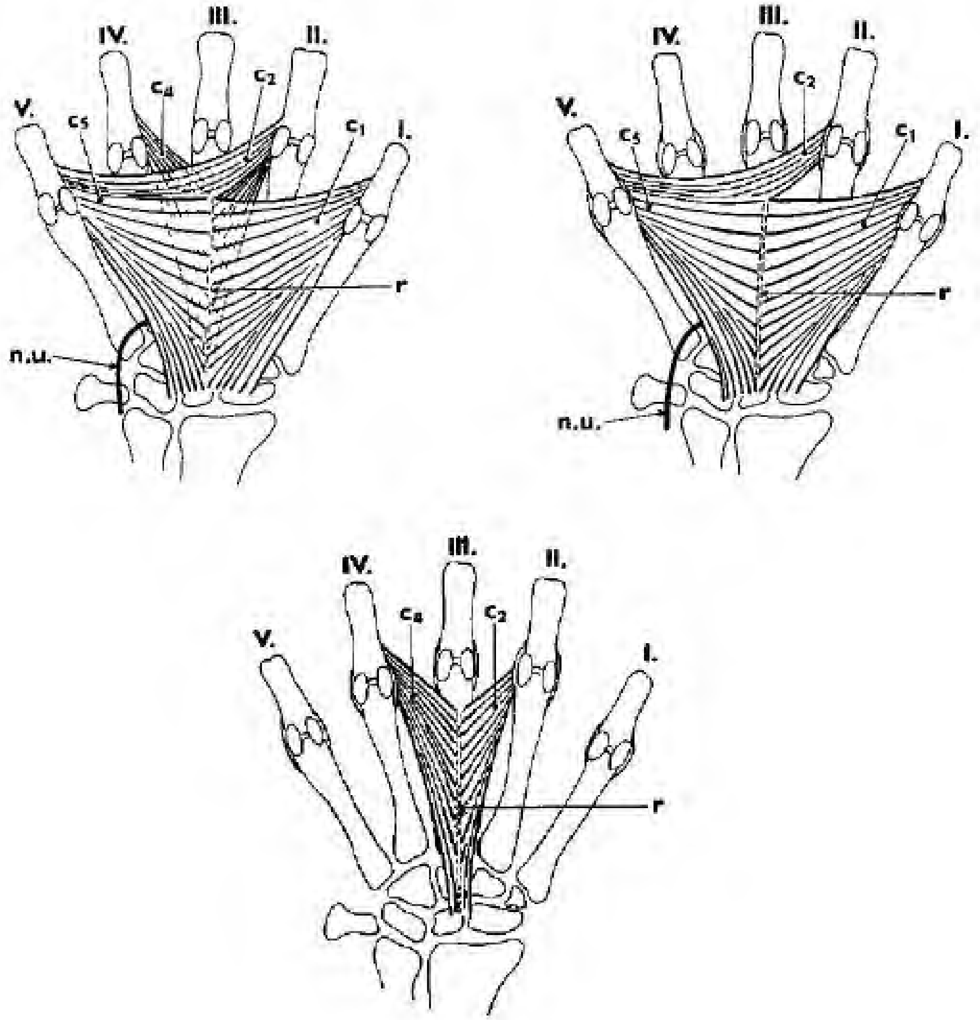
DISCUSSION

Muscles of autopodium of *Monodelphis domestica* were not described yet but the comparison of our results with findings of several authors, who described muscles of another species of family Didelphidae is available. Young (1880), Leche (1900), Kajava (1911), Forster (1916) and Čihák (1963) demonstrated the extent and the pattern of contrahent muscle layer being in details the very similar as was found in *Monodelphis domestica*. Only Coues (1878) describes in *Didelphis virginiana* two mm. contrahentes (adductores) splitting from the fibrous raphe to the 1st and to the 5th fingers. We suppose that the author considered the thin deeper part of layer of mm. contrahentes going to the 2nd and 4th fingers to belong to the deep short flexors and called them mm. interossei palmares.

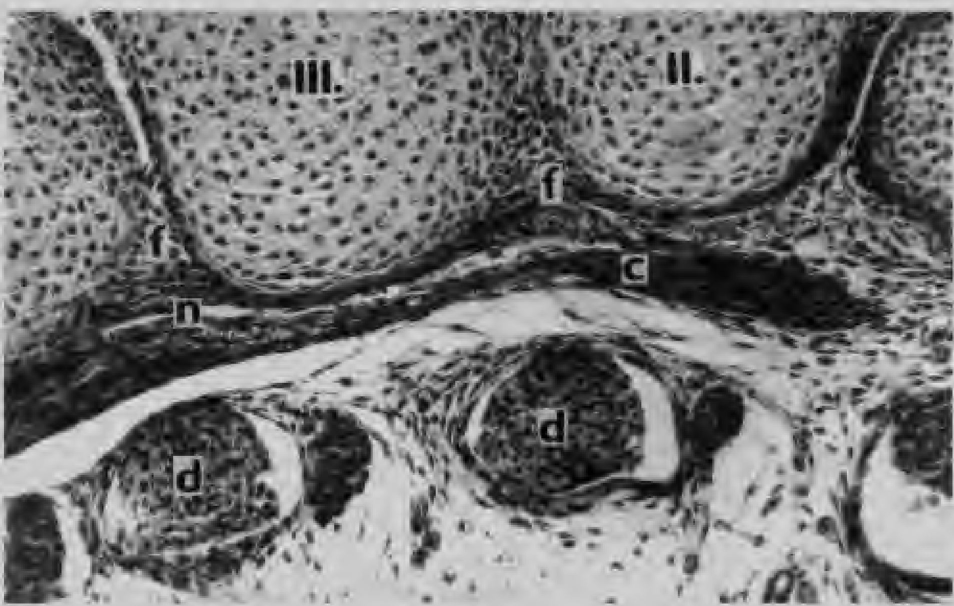
On the base of analysis of informations about the pattern of the contrahent muscle layer in the other species of Marsupialia it could be concluded that in most cases the extent and the pattern of studied layer was the same or very similar in the whole order (Cunningham 1878, Young 1880, Leche 1900, Ribbing 1909, Kajava 1911). The layer consisted of four contrahent muscles inserting to the 1st, 2nd, 4th and 5th fingers. That is the maximal number of these muscles observed in mammals.

No informations dealing with the ontogeny of the muscles of autopodium in *Monodelphis domestica* were available. That was why we could not compare our results in this field with literature. We found that in early stages of ontogenesis of the forelimb muscle layers were arranged according to the common scheme of the pattern of mammalian hand which was published by Bardeleben (1890) and supplemented by Čihák (1969) and Dylevský (1971).

The primordium of mm. contrahentes layer found in the whole extent of the palm and during the next development it undergoes gradual differentiation and forming. The finding that no process of reduction takes place in the ontogeny of contrahent muscle layer in *Monodelphis domestica* is the most important results of our study. The layer persisted in the whole extent of



Figs 1–3 Schemes of the contrahent muscles of *Monodelphis domestica*
Fig 1 (above left) – scheme of the contrahent muscle layer Fig 2 (above right) – scheme of the superficial part of the contrahent muscle layer Fig 3 (below) – scheme of the deeper part of the contrahent muscle layer Explanations I–V – first to fifth digits, r – fibrous raphe, n u – r palmaris profundus nervi ulnaris, c_1, c_2, c_4, c_5 – mm contrahentes digiti I, II, IV et V



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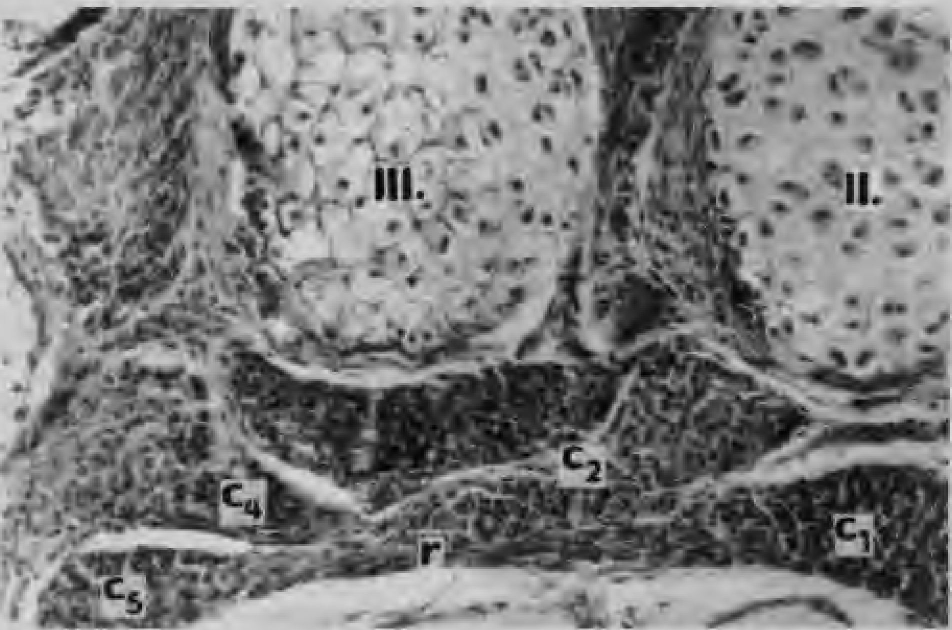

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Figs 4 and 5. Transverse section through the autopodium of *Monodelphis domestica* the 1st postnatal day (4) and the 7th postnatal day (5). Explanations: II., III. – the 2nd and the 3rd metacarpal bones; f – anlage of mm. flexores breves profundi, n. – r. palmaris nervi ulnaris; c – anlage of the mm. contrahentes layer; d – tendons of m. flexor digitorum profundus, c_1, c_2, c_4, c_5 – mm. contrahentes digiti I., II., IV. et V.; r – fibrous raphe). 150×.

the palm contrary to some other mammalian species. In the ontogeny of forelimb of Sorex araneus, Myotis myotis, domestic cat, laboratory rat and also in human hand we could see the common continuous blastema of studied layer in early stages of ontogenesis. Then the anlage undergoes the process of reduction in details specific in different species, but always keeping consequence of morphogenetic changes (Čihák 1963, 1967, 1969, 1972, 1991, Trnková & Dylevský 1969, 1971, 1972, 1984, Trnková 1972, 1973, 1974, Grim 1972, Mrázková 1983).

On the base of comparison of all previous findings it can be concluded, that the pattern of mm. contrahentes layer in the whole extent of the palm and its dividing into the four muscles going to the 1st, 2nd, 4th and 5th fingers is the situation phylogenetically ancient and deeply fixed in the ontogeny of mammalian autopodium.

Acknowledgements

This paper was finished when autors were working on the Institute of Anatomy, 1st Faculty of Medicine, Charles University, Prague. The autors thank our collegues from Anatomical Institute, Medical Faculty, Hamburg, Germany, for the material under study.

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Acta Soc. Zool. Bohem. 60: 63–71, 1996
ISSN 0862-5247

On the bats (Mammalia: Chiroptera) of Albania: survey of the recent records

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Received January 2, 1996; accepted February 29, 1996
Published April 5, 1996

Abstract. New records of bats from Albania are reported with a brief survey of the previous data. *Myotis bechsteini*, *M. mystacinus*, *M. daubentoni*, *Pipistrellus pipistrellus* and *Vespertilio murinus* are new for Albania, by which the number from there reported bat species increases to 24.

Distribution, bats, Albania, the Balkans

INTRODUCTION

In comparison with neighbouring countries, bat fauna of Albania is poorly known. The most important data were provided in sixties by Hanák et al. (1961) and Hanák (1964), and latter supplemented by Lamani (1970). Bat ectoparasites obtained from Hanák's and German collection were described by Hůrka (1962, 1963). Since then, only two papers dealing with Albanian bats have appeared: Bego & Griffiths (1994) summarized in new the previously published data (cf. o. c.) and Chytil & Vlašín (1994) provided a brief account of several original records they recently obtained. The material of collected specimens has partly been used also in several biometrical and taxonomical studies (Felten et al. 1977, Kryštufek 1993, Benda & Horáček 1995a, b). Based on all these literary sources, in total 19 species of bats were proved to occur in the country.

The present report supplements these data with new records obtained in Albania during short trips in 1992 and 1995. Standard field sampling techniques (visual controls of potential roosts, mist netting – mostly in cave entrances) were supplemented also by a monitoring of bats during night activity with aid a bat detector (Pettersson D 100, QMC Mini).

SURVEY OF RECORDS

Rhinolophus ferrumequinum (Schreber, 1774)

ORIGINAL DATA:

(1) Dajti Mts., small village Linza in surroudings of Tirana, 8 abandoned military tunnels, 9 April 1995: 1 s. i., torpid;
(2) Fushe Gropa e Perrenjasit Mts., 5 km W from Ochrid lake, Kishes cave, 19 April 1995: 1m ad. torpid;
(3) Micro Prespa cave (870 m a. s. l.), 21 April 1995: 2m, 1f netted in cave entrance;
(4) Mezhgoranit cave 10 km E Tepelene town, 22 April 1995: mixed colony with *Miniopterus schreibersi*, *Myotis capaccinii* and *R. blasii*, 3m and 1f of *R. ferrumequinum* netted;
(5) Gjere Mts., Haskova and Dhuvjani villages, system of abandoned military tunnels, 24 April 1995: 20 ind. observed/detected, 1 ind. torpid;
(6) Butrint ancient town, cellar, 25 April 1995: 1 torpid s. i. observed;

(7) Robit Mts., two military tunnels, 27 April 1995 2 activ adult males, 1 torpid s. i.,
(8) Dajti Mts., Pellumbasi village, Zezä cave, 28 April 1995: colony of *R. ferrumequinum* approx. 5000 individuals, partly in lethargy, 1m and 2f netted;
(9) Cikes Mts., Himara cave, 25 April 1995 1 ind. observed
(10) Apolonia, underground spaces in ancient excavations, 5 October 1992: 1 ind. observed
LITERARY DATA: (11) Cervenak cave, (12) Igor cave near Pishkash, (13) Velca cave, (4) Mezhgoranit cave, (14) Fush-Kruje cave, (15) Vanista cave, (16) Ali Dedar Cave, (1) Dajti Mts. near Tirana (Hanák et al. 1961, Hanák 1964, Chytil & Vlašín 1994)

In Albania, *R. ferrumequinum* was recorded in 16 sites, 8 being reported first in the present paper. Mixed breeding colonies of this species (with *R. euryale, R. blasii, M. blythi, M. myotis*), amounting to 100–300 ind., has already been reported from Albania by Hanák (1964). We found such a type colonies in two caves: Mezhgoranit (with about 1000 ind.) and Zezä (about 5000 ind. of *R. ferrumequinum*). Noteworthy is appearance of torpid bats in April, recorded in several sites. Ten individuals netted in cave entrances were mostly males (1.5m : 1.0f), a pregnant female from Zezä cave proves a reproduction in the locality. In general, this species seems to be one of commonest bats in karst regions, similarly as it is the case in neighbouring countries (cf. e. g. Kryštufek 1991, Červený & Kryštufek 1988, Kryštufek et al. 1992, Horáček et al. 1974). Measurements of the individuals caught: W: 7 m: 17.0–19.14–20.5, 3 f: 21.5–23.4–26.75, FA: 7 m: 55.5–58.24–60.8, 2 f: 59.6, 60.3.

Rhinolophus hipposideros (Bechstein, 1800)

ORIGINAL DATA:
(1) Dajti Mts., small village Linza in surrounding of Tirana, 8 abandoned military tunnels, 9 April 1995: 2 torpid individuals,
(2) Macro Prespa lake, small cave 1 km E from Gollombaci village, 20 April 1995: 1m subadult, 1f subadult (both torpid inside the cave);
(3) Mali i Skendereut Mts. NE of Tirana, a small cave at a road km 22, 3 October 1992: 1f ad. netted.
LITERARY DATA: (1) Dajti Mts. near Tirana, (4) Mikro Prespa cave (Chytil & Vlašín 1994).

This species was first recorded in 1991 by Chytil & Vlašín (1994). In total, only 5 records in 4 sites, all situated in medium altitudes, 700–870 m a. s. l., are available. Judging of the situation in neighbouring countries, *R. hipposideros* can be expected to occur regularly in Albania, though not so frequently as the other species of the genus. Measurements of the specimens sampled: W: 1 m: 4.5, 1 f: 5.25, FA: 1 m: 40.2, 1 f: 40.4.

Rhinolophus euryale (Blasius, 1853) and ***Rhinolophus blasii*** (Peters, 1866)

ORIGINAL DATA:
The medium sized horseshoe bats were observed in the following sites:
(1) Micro Prespa cave, 21 April 1995: 1 male and 1 female of *R. blasii* netted;
(2) Mezhgoranit cave near Tepelene 22 April 1995: 1 male and 8 female of *R. blasii* netted;
(3) Gjere Mts., Haskova–Dhuvjani village, system of abandoned military tunnels, 24 April 1995: 2 undeterminated medium sized specimens observed/detected (approx. 110 kHz);
(4) Butrinti ancient town, cellar, 25 April 1995. 1 activ undetermined specimen observed;
(5) Macit cave near Velce village, 26 April1995: colony of 2000 individuals observed, 1 male of *R. blasii* captured inside cave,
(6) Robit Mts., two military tunnels, 27 April 1995: observed approx. 20 activ individuals, 1 adult female of *R. euryale* captured;
(7) Dajti Mts., Pellumbasi village, Zezä cave, 28 April 1995: 700–1000 individuals observed in colony, 1 male of *R. blasii* netted
LITERARY DATA: *R. euryale*: Igor cave near Pishkash, Mezhgoranit cave, Himara cave, Fuse-Kruja cave (Hanák et al. 1961, Hanák 1964). *R. blasii*: Pishkash cave, Mezhgoranit cave, Korita cave (Hanák et al. 1961, Hanák 1964).

R. blasii was proved in five of the sites in which the medium-sized horseshoe bats were observed. A large colony amounting to 2000 individuals was found in Macit cave, a smaller one in Zezä cave (Dajti Mts.). Hanák (1964) reported from Albania also mixed colonies of both *R. blasii* and *R. euryale*. Both the species were reported also from neigbouring countries (e. g. Kryštufek et al. 1992). In our material, *R. euryale* is represented only with one female caught from a small colony (ca 20 ind.) roosting in a military construction Eastern of Tirana.

Myotis bechsteini (Kuhl, 1818)

Original datum

(1) Gjere and Stugares Mts., Bistrices valley - Blue Eyes water spring (Syri i kalter), 11 km SE from Delvine town, plane-tree forest, 24 April 1995: 1 adult male netted

M. bechsteini was netted over a water spring Syri i kalter in piedmonts of Gjere and Studares Mts., inside a dense humid *Platanus* woodland. This is the first record in Albania. *M. bechsteini* ranks among the rarest species also in the other regions of Balkans (Hanák & Josifov 1959, Horáček et al. 1974, Helversen & Weid 1990, Kahmann 1962). Until now, it absents in Montenegro, Bosnia and Macedonia. More records are available from Greece, mostly of the habitats similar to that in Albania (Helversen & Weid 1990).

Fig. 1 Sketch map of the localities studied. 1 – Dajti Mts., Linza village, 2 – Kishes cave; 3 – Mikroprespa cave; 4 – Mezhgoranit cave; 5 – Haskova, Duvjani villages; 6 – Butrinti; 7 – Robit Mts.; 8 – Zezä cave; 9 – Himara; 10 – Gollombaçi; 11 – Velca cave; 12 – Bistrices valley; 13 – Gjirokaster; 14 – Vanishter cave; 15 – Tirana; 16 – Leske; 17 – Skenderout Mts.; 18 – Apolonia, 19 – Libohove.

Myotis blythi (Tomes, 1857)

ORIGINAL DATA:
(1) Mezhgoranit cave near Tepelene, 22 April 1995: 2 ff netted;
(2) Gjirocaster castle, dark corridors, 23 April 1995. 5 ff netted;
(3) Vanisther cave, 23 April1995 10 ind. netted (5/5);
(4) Macit cave near Velca village, 26 April 1995: from large mixed colony: 3 specimens of *M. blythi* netted;
(5) Dajti Mts., Pellumbasi village, Zezä cave, 28 April 1995, 5 females netted.
LITERARY DATA (1) Mezhgoranit cave, (6) Shkembi and Kavaje cave, (2) Gjirokaster castle (Hanák et al. 1961, Hanák 1964, Chytil & Vlašin 1994).

In Albania, this species was found in six localities, all caves except for Gjirokaster castle. In the samples mist-netted in roosts of cave-dwelling mixed colonies, *M. myotis* to *M. blythi* ratio was 2.2:1. A large mixed colonies of both species (including also *Miniopterus schreibersii* and *Myotis cappacinii)* was found in underground tunnels of Gjirocaster castle, the site in which Chytil & Vlašín (1994) found a sole individual of *M. blythi* only. Anyhow, in Micro Prespa cave only *M. myotis* was found while in Mezhgoranit cave we netted only *M. blythi*. Sex ratio in the total sample netted in cave roosts was 1:3.1 (m:f). Metric data of the sample obtained: W: 7 m: 20.75–22.28–25.75, 12 f: 19.5–22.0–25.5, FA: 13 f: 48.2–58.0–60.2, 5 m: 55.5–58.5–64.8.

Myotis myotis (Borkhausen, 1797)

ORIGINAL DATA:
(1) Micro Prespa cave, 21 April 1995: 5 individuals netted (2m, 3f);
(2) Mezhgoranit cave near Tepelene, 22 April 1995: 3 adult females netted;
(3) Gjirocaster castle, dark corridors, 23 April 1995: mixed colony of *M. myotis, M. blythi, M. capaccinii* and *Miniopterus schreibersi* with 800 individuals observed, 4 adult females netted;
(4) Vanisther cave, 23 April 1995 9 ind. netted (1m, 8f);
(5) Macit cave near Velca village, 26 April 1995. colony of *Myotis myotis* and *M. blythi* 5000–7000 ind., 19 ind. netted (3/16),
(6) Robit Mts., two military tunnels, 27 April 1995, 2 adult males in letargy;
(7) Dajti Mts., Pellumbasi village, Zezä cave, 28 April 1995: 15 ind. netted (1/14)
LITERARY DATA: (2) Mezhgoranit cave, (4) Vanister cave, (8) Fush-Kruje cave, (9) Shales, (10) Divjaka (Hanák et al. 1961, Hanák 1964).

We found this species in 7 localities (5 caves, 2 artifical underground spaces), two of which were already mentioned by previous authors. Thus, in total, *M. myotis* has been recorded in 10 sites in Albania, frequently forming mixed colonies with the preceding species. Similarly as in Macedonia (cf. Kryštufek et al. 1992) it seems, however, it is more frequent than *M. blythi*. In the samples netted in entrances of the caves occupied by breeding colonies, sex ratio was 1:6.9 (m:f). Metric data were as follows: W: 7 m: 20.0–24.5–27.5, 34 f: 18.5–25.4–29.5, FA: 8 m: 55.9–59.8–61.9, 34 f: 48.6–62.1–66.0,

Myotis nattereri (Kuhl, 1818)

No own records.
LITERARY DATUM: Morave Mts., Barca village (Chytil & Vlašín 1994).

Myotis emarginatus (Geoffroy, 1806)

No own records.
LITERARY DATUM: Konte cave (Hanák 1964)

Tab. 1. Species composition and abundance the sites occupied by bat colonies. V. c. – total visual census, T – netting time

Locality (date)	V. c.	T	sex	*R. fer*	*R. bla*	*M. sch*	*M. myo*	*M. bly*	*M. cap*	*M. dau*	*E. ser*	Total
Micropresa cave	1000	4.36	m	2	1	5	2	–	17	12	1	85
(21 April 1995)			f	1	1	3	3	–	37	–	–	
Mezhgoranit cave	1000	3.00	m	3	1	7	–	–	–	–	–	33
(22 April 1995)			f	1	8	7	3	2	1	–	–	
Vanishter cave	unknow	2.30	m	–	–	16	1	5	10	–	–	84
(23 April 1995)			f	–	–	15	8	5	24	–	–	
Macit cave	10 000	2.50	m	–	1	2	3	1	–	–	–	31
(26 April 1995)			f	–	–	6	16	2	–	–	–	
Zezä cave	6500	3.30	m	1	1	31	1	–	1	–	–	78
(27 April 1995)			f	2	–	16	14	5	6	–	–	
Gjirokaster	800	2.00	m	–	–	5	–	–	6	–	–	31
(23 April 1995)			f	–	–	8	4	5	3	–	–	
Total				10	13	121	55	25	105	12	1	342

Myotis mystacinus (Kuhl, 1819)

ORIGINAL DATUM:

(1) Libohove near Gjirokaster, a larger cave in a right slope of the valley, 6 October 1992: 1 subadult male netted.

This is apparently the first record of this species in Albania. Its absence in the previous material is a bit surprising especially in comparison with the neighbouring countries in which *M. mystacinus* is represented with relatively large number of records covering nearly all mountain and submountain regions (Kryštufek et al. 1992, Horáček et al. 1996).

Myotis daubentoni (Kuhl, 1819)

ORIGINAL DATA:

(1) Macro Prespa lake, small cave 1 km SW from Gollombaçi village, 20 April 1995: 2 adult females netted;
(2) Micro Prespa cave, 21 April 1995: 12 males netted.

These are the first records of *M. daubentoni* in Albania. In general, it is quite a rare species in whole region of SE-Europe (cf. e. g. Červený & Kryštufek 1988, Kryštufek et al. 1992 a. o.). Nevertheless, in the recent years, number of its records markedly increased (cf. Helversen & Weid 1990, Horáček et al. 1996) which may, even for this region indicate the same trend that in the Central and Western Europe occured since seventies (cf. Daan et al. 1980, Gaisler et al. 1981). Both the Albanian records come from the sites closely neighbouring large water reservoirs, i. e. just the habitat preferred by this species.

Myotis capaccinii (Bonaparte, 1837)

ORIGINAL DATA:

(1) Macro Prespa lake, small cave 1 km SW from Gollombaçi village, 20 April 1995: 1 adult female and 1 adult male netted;
(2) Micro Prespa cave, 21 April 1995: colony with approximately 1000 individuals observed: 54 individulas netted (17m, 37f);

(3) Mezhgoranit cave near Tepelene, 22 April 1995: 1 female netted;
(4) Gjirocaster castle, dark coridors, 23 April 1995: colony observed: 6 males and 3 females netted;
(5) Vanishter cave, 23 April 1995: 34 ind. netted, 10 males, 24 females;
(6) Dajti Mts., Pellumbasi village, Zezä cave, 28 April 1995: 7 ind. netted (1m, 6f)
LITERARY DATA: (3) Mezhgoranit cave, (2) Mikro Prespa cave (Hanák et al. 1961, Hanák 1964, Chytil & Vlašin 1994).

Chytil & Vlašin (1994) who discovered a colony of this species in Micro Prespa cave on May 30, 1991, found there about 10 000 individuals, which they consider to be the largest known colony of *M. capaccini* in Europe. In time of our visit (21 April 1994), we found in that site about 1000 individuals. Large colonies were also recorded in Gjirokaster, Mezhgoranit, Vanishter and Zezä caves. In all instances, *M. capaccini* appeared together with other species in mixed colonies (Tab. 1). In total sample we obtained (107 ind.) sex ratio was 1:2.1 (m:f).

Eptesicus serotinus (Schreber, 1774)

ORIGINAL DATA:
(1) Macro Prespa lake, small cave and abri 1 km SW from Gollombaçi village, 20 April 1995: 2 adult males netted,
(2) Micro Prespa cave, 21 April 1995: 1 adult male netted;
(3) Mezhgoranit cave near Tepelene, 22 April 1995: several invidiuals detected before cave entrance;
(4) Libohove near Gjirokaster, a larger cave in a right slope of the valley, 6 October 1992: 1 ind. s. i. observed.
LITERARY DATA: (5) Tirana (Hanák 1964, Lamani 1970).

E. serotinus ranks among very characteristic species in all xeric and semi-xeric habitats of the SE-Europe, including human settlements. In respect to overall number of Albanian bat records, 5 records of this species seems to indicate it ranks among relatively common species also in this country.

Hypsugo savii (Bonaparte, 1837)

ORIGINAL DATA
(1) Macro Prespa lake, small cave 1 km SW from Gollombaçi village, 20 April 1995: 2 males netted;
(2) Apolonia near Fier, a monastery, 4 October 1992: 1–2 ind. detected;
(3) Libohove near Gjirokaster, a larger cave in a right slope of the valley, 6 October 1992: 4 ind. detected and observed.
LITERARY DATUM (4) Tirana (Lamani 1970, Hanák 1964)

This species seems to be relatively common species in all rocky regions of SE-Europe. Anyhow, as a lithophilous form it can only hardly be discovered when only the tradition sampling techniques are applied. This may explain its rarity in the Balkans record prior to seventies. With aid of mist nettings and bat detectoring in rocky habitats, number of its records has considerably increased. Judging of the availability of rocky habitats, Albania may be looked upon as a very suitable country for this species and further records are to be expected for sure.

Vespertilio murinus (Linnaeus, 1758)

ORIGINAL DATUM:
(1) Mali i Skenderecit Mts. NE of Tirana, road km 22, 3 October 1995: detected 1 individual flying over the rocks (performing a characteristic display – cf. Weid 1988)

This is the first record of this species in Albania. For *V. murinus*, almost the same holds as said in the preceding species. Its abundance in the Balkans has undoubtedly been greatly underestimated. As in other lithophilous species, application of advanced methods (bat detectoring in particular) during the last decade proves it is much more frequent than one tended to expect based on scarcity of actual records in the preceding period.

Pipistrellus pipistrellus (Schreber, 1774)

ORIGINAL DATUM:
(1) Tirana, 17 September 1994: Ferdinand Bego sampled 1 male when flying in a window of a flat.

Surprisingly, also in case of this species, which otherwise ranks among the commonest bats in Balkans, this one is the first record in Albania. However it is impossible under current state of knowledge to draw any conclusion of the absence *P. pipistrellus* in the previous records, in comparison with neighbouring countries it is indeed a strange fact. One can not exclude that its abundance in Albania is generally smaller than that of *P. kuhli*.

Pipistrellus nathusii (Keyserling et Blasius, 1839)

No own record.
LITERARY DATUM: Rrushkuli (Hanák et al. 1961, Hanák 1964).

Pipistrellus kuhli (Kuhl, 1819)

ORIGINAL DATA:
(1) Tirana, a street in diplomatic quater, 30 September 1992: 1 ind. detected;
(2) Leske, swampy meadows and shore of a lake, 1 October 1992: in total about 13 hunting individuals detected and observed.
LITERARY DATUM: (3) Tirana (Hanák 1964).

Nyctalus leisleri (Kuhl, 1818)

No own record.
LITERARY DATUM: Albania (Lamani 1970).

Nyctalus noctula (Schreber, 1774)

No own record.
Literary data: Tirana, Shkodra, Dajti Mts. (Hanák et al. 1961, Hanák 1964, Chytil & Vlašín 1994).

Plecotus auritus (Linnaeus, 1758)

No own record.
LITERARY DATUM: Tirana (Lamani 1970).

Plecotus austriacus (Fischer, 1829)

No own record.
LITERARY DATA: Tirana, Elbasan (Hanák et al. 1961, Hanák 1964).

Miniopterus schreibersi (Kuhl, 1819)

ORIGINAL DATA:
(1) Micro Prespa cave, 21 April 1995: 8 ind. netted (5m, 3f);
(2) Mezhgoranit cave near Tepelene, 22 April 1995: mixed colony (*M. schreibersi, Rhinolophus ferrumequinum, R. blasii, Myotis capaccinii*): 14 ind. netted (7m, 7f);
(3) Gjirocaster castle, dark coridors, 23 April 1995: mixed (*M. blythi*) colony observed: 5m, 8f netted;
(4) Vanisther cave, 23 April 1995: 16m, 15f netted;
(5) Macit cave near Velca village, 26 April 1995: colony of 2000 ind. observed: 2 males, 6 females netted;
(6) Dajti Mts., Pellumbasi village, Zezä cave, 28 April 1995, observed ca. 15 ind. torpid inside cave, 31 m and 16 f netted.
LITERARY DATA: (2) Mezhgoranit cave, (4) Vanister cave, (7) Fush-Kruje cave, (8) Shkembi i Kavje Caves, (1) Mikro Prespa cave, (9) Morave Mts. Barca village (Hanák et al. 1961, Hanák 1964, Chytil & Vlašín 1994).

With nine records, *M. schreibersi* ranks among the most frequent bats in Albania. It is undoubtedly due to it forms mass breeding colonies in caves which always attract interest. In the sample of bats netted in entrances of the caves occupied by bat colonies (Tab.1), *M. schreibersi* appeared as a dominant species (37.3%). Its sex ratio in that material was 1.2:1 (m:f). The largest colony, in Macit cave, amounted to ca. 2000 individuals. Metrical data were as follows: W: 38 m: 8.75–11.9–13.75, 45 f: 10.5–12.5–14.5, FA: 36 m: 42.3–45.7–47.3, 44 f: 41.0–45.9–47.3

Tadarida teniotis (Rafinesque, 1814)

ORIGINAL DATA
(1) Apolonia near Fier, ancient monastery, 4 October 1992 at least 2 ind. repeatedly detected and observed,
(2) Libohove near Gjirokaster, rocky slopes of the valley, 6 October 1992. at least 1 ind. repeatedly detected
LITERARY DATUM: Elbasan (Lamani 1970)

This is a strictly lithophilous species, extremely specialized to aerial foraging. Although, it is almost impossible to discover it with aid of traditional sampling techniques, it is quite easy to detect it acoustically when on fly. Two records we obtained by means of that techniques indicate this is a regular species in Albania though perhaps not as much common as one would tend to expect.

CONCLUSIONS AND DISCUSSION

With *Myotis bechsteini, Myotis mystacinus, Myotis daubentoni, Pipistrellus pipistrellus* and *Vespertilio murinus* which are reported from Albania first in this paper, the number of Albanian bat species increased to 24. Thus, now the species list of Albanian bats approaches close to expectation (corresponding to a state recorded in the neighbouring countries). In any case, until now, number of records is quite a low (9 species being evidenced by just a sole record only) and, thus, it is apparently impossible to state almost anything about real abundances of individual species and/or about geographic specificities of respective bat communities in different parts of the country, etc. The available record is unbalanced also due to limited application of other research techniques than inspecting of caves and sampling of cave colonies. The first efforts combining mist-nettings and bat detectoring that has been performed in frame of our excursions was proved very succesfull and it should be there applied more systematically.

Out of the species not reported from Albania, *Rhinolophus mehelyi, Nyctalus lasiopterus, Barbastella barbastellus* and *Myotis brandti*, found in the neighbouring regions, come here in account (the latter two especially in high mountain regions of NE and E Albania, from where no bat records are available as yet).

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Acta Soc. Zool. Bohem. **60**: 73–81, 1996
ISSN 0862-5247

Communities of small terrestrial mammals in two lowland forest ecosystems of Litovelské Pomoraví, Czech Republic

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Received September 23, 1995; accepted February 29, 1996
Published April 5, 1996

Abstract. In a floodplain and a lime-hornbeam forest in the Protected Area of Litovelské Pomoraví an investigation of small terrestrial mammal communities was performed during three subsequent years. In snap-traps and pitfall-traps a total of 523 individuals of 7 species were caught in the floodplain forest and 160 individuals of 5 species in the lime-hornbeam forest. In the first habitat the highest dominances were found for *Apodemus flavicollis* (60.7%), *Clethrionomys glareolus* (22.5%) and *Apodemus sylvaticus* (14.3%); in the latter these were *C. glareolus* (38.2%), *A. flavicollis* (30.6%), *A. sylvaticus* (15.3%) and *Sorex araneus* (13.2%). For the species *A. flavicollis*, *A. sylvaticus* and *C. glareolus* the relative abundance was calculated in each catch period and forest type. The relative abundance of the community was higher in the floodplain forest (22.9 ind. per 100 trap-nights) than in the lime-hornbeam forest (6,9 ind. per 100 trap-nights). The mean index of species diversity (H'=1.23 vs. H'=0.94) and the index of equitability (E=0.67 vs. E=0.51) were higher in the first habitat, too.

Community ecology, lowland forest, Insectivora, Rodentia

INTRODUCTION

Natural lowland forest ecosystems belong to the most productive ones, but at present also to the most endangered in Central Europe. Floodplain forests have so far remained only in narrow stripes along the rivers. This is mostly caused by river channelization, intensive farming and unsuitable forest management. There is still continual impair of further deterioration of river floodplains by activities such as river channelization, dam construction etc.

For these reasons investigations of these ecosystems are of major importance. Research of small mammal communities in the lowland forest was carried out close to the confluence of Vltava and Labe rivers in central Bohemia (Čiháková et al. 1993), along Svratka river near Vranovice , along Morava river near Hodonín (Zejda 1973, Pelikán et al. 1974) and near Kroměříž (Chytil 1981), along Dyje river (Zejda & Pelikán 1969, Zejda 1976, Šebela 1980) in south Moravia, in lowlands in near to Opava in northern Moravia (Pelikán et al. 1974). The synusy of small mammals in Slovakia was investigated by Májsky (1985) on Žitný ostrov in the Danubian lowland and by Dudich & Štollmann (1983) in the east lowlands along the rivers Laborec, Latorica, Uh and Bodrog.

Litovelské Pomoraví Protected Landscape Area is an area of international importance (Hudec et al. 1993) with relative well preserved forest ecosystems and with an inland delta of Morava River with numerous affluents and branches. Research has been carried by specialists from Palacký University Olomouc and Institute of Landscape Ecology in Brno. In mammalogical respect only one faunistic study by Rumler (1988) is known comes from this territory.

STUDY AREA

Investigations were carried out in two forest ecosystems situated in the Litovelské Pomoraví Protected Landscape Area (northern Moravia).

1. Floodplain forest
The locality is situated about 2,5 km south-east of the village Střeň, on alluvial plain between the Morava River and the Benkovsky brook. The altitude of the locality is 228 m and the exposition 0°. It is in antecedent years regulary flooded forest of the ass. *Ficario–Ulmetum campestris* Knapp ex Medwecka-Kornas 1952, subass. *typicum* (Passarge 1958) Neuhauslová-Novotná 1982. According to Randuška et al. (1986) this community belongs to a group of forest types named *Ulmeto-Fraxinetum populeum*. A more detailed phytocenological characteristic can be found in the paper by Janošková (1988). Regulation of some parts of the Morava River with its affluents was performed in the seventies and eighties, one close to the study site. As a consequence decline of ground water occurred and there were also changes in the flood pattern especially a reduction of high peaks of flood in the time of research.

2. Lime-hornbeam forest
The locality is situated in a forest complex called „Doubrava", about 5 km north-west of the village Červenka, close to the railway Olomouc – Česka Třebová. The altitude of the locality is 250 m and the exposition 0°. It is a not flooded lime-hornbeam forest of the ass. *Tilio–Carpinetum* sensu Traczyk 1962 subass. *Molinietosum arundinaceae* Neuhausl et Neuhauslova-Novotná 1972 and it belongs to 1st oak vegetation tier. A detailed description of the locality under study is to be found in Kmel (1989).

MATERIAL AND METHODS

The field work was carried out from spring 1992 to autumn 1994. In total 683 individuals belonging to 8 species were caught during the three-year study in both localities. Insectivora: *Sorex araneus* Linne, 1758, *S. minutus* Linne, 1766, *Talpa europaea* Linné, 1758, Rodentia: *Apodemus flavicollis* (Melchior, 1834), *A. sylvaticus* (Linné, 1758), *A. agrarius* (Pallas, 1771), *Clethrionomys glareolus* (Schreber, 1780), *Pitymys subterraneus* (de Sélys-Longchamps, 1836).

Tab. 1. Survey of the total catch of small mammals. Explanations: N – number of individuals, D – dominance, C – constancy, RA – relative abundance.

Species	Snap-traps (1992–1994)								Pitfall-traps (1993)			
	Floodplain forest				Lime-hornbeam forest				Floodplain forest		Lime-hornbeam forest	
	N	D%	C%	RA	N	D%	C%	RA	N	D%	N	D%
S. araneus					19	13.2	36	0.91	3	6.4	8	50
S. minutus					4	2.8	27	0.19			2	12.5
T. europaea									1	2.1		
A. flavicollis	289	60.7	100	13.9	44	30.6	82	2.1	19	40.4	1	6.3
A. sylvaticus	68	14.3	82	3.3	22	15.3	64	1.1	10	21.3	2	12.5
A. agrarius	4	0.8	27	0.19								
C. glareolus	107	22.5	91	5.2	55	38.2	46	2.7	10	21.3	3	18.8
P. subterraneus	8	1.7	46	0.39					4	8.5		
Total	476	100	–	22.9	144	100	–	6.9	47	100	16	100
Number of trap-nights		2079				2079				588		588
Diversity H'		1.23				0.94						
Equitability E		0.67				0.51						

The common type of snap traps (size 10×5 cm) were used. The traps were laid in three 100 meter long lines at a distance of 5 meters, i. e., 63 traps were exposed in each trapping. The display time was always 3 nights (see Pelikán 1975), in every season at a different place. Traps were baited with a standard bait, pieces of wick fried in fat and flour.

In 1992 the trapping was performed three times a year: May 12–15 in floodplain forest and 19–22 in the lime-hornbeam forest, August 18–21 and 24–27, in October 25–28 and November 2–5. In the following years the research was carried out four times per year: in 1993 in spring (April 20–23 and 26–29), summer (June 23–26 and 26–29), late summer (August 2–5 in both forests) and autumn (November 9–12 and 2–5), in 1994 in both forests at the same date: in spring (April 21–24), summer (June 27–30), late summer (August 8–11) and autumn (October 23–26).

In addition to the 3 lines of snap-traps, one line of pitfall traps with the same parameters was exposed in 1993. The reason was an objective judgement of shrew presence (Pelikán et al. 1977). The pitfall traps were open for seven days, in April 20–27, in June 18–25, from July 30 to August 6 and in November 9–16. Material from the pitfall traps was used only for a review of the species composition of the community and it was not incorporated in the quantitative characteristics of these synusy. Indices of species diversity and equitability were calculated according to Brower et al. (1990), in $\log_2$. Mean values were calculated from the individual samples. The value of relative abundance was expressed by the number of individuals caught in 100 traps per night. For the species *Apodemus flavicollis*, *Apodemus sylvaticus* and *Clethrionomys glareolus* the relative abundance was calculated in each catch period and forest type. The material is deposited in the collections of the Department of Ecology, Palacký University, Olomouc.

RESULTS

1. Floodplain forest

In total 7 species of small terrestrial mammals were found during three years of investigations *S. araneus, T. europaea, A. flavicollis, A. sylvaticus, A. agrarius, C. glareolus, P. subterraneus*. The mean value of the index of species diversity was H'=1.23. The highest species diversity was found in summer 1994 (H'=1.66). The lowest was found in spring 1993, when only *A. flavicollis* in minimum population density was found in the locality. The mean value of equitability was E=0.67. The highest value was found in summer 1992 (E=0.93).

In the entire material of 476 individuals, the eudominant species *A. flavicollis* (60.7%), *C. glareolus* (22.5%) and *A. sylvaticus* (14.3%) had the highest value of dominance. *P. subterraneus* (1.7%) was recedent. *A. agrarius* (0.8%) occurred in the area in August 1992 as well as in June 1993, 1994 and was a subrecedent species. In the aspect of constancy, *A. flavicollis, A.*

Tab. 2. Number of captured individuals (N) and relative abundance (RA) of *Apodemus flavicollis* computed for the total material and for the first trapping day only (n1, ra1)

		Floodplain forest				Lime-hornbeam forest			
		n1	ra1	N	RA	n1	ra1	N	RA
May	1992	8	12.7	17	9.0	1	1.6	2	1.10
Augus	1992	20	31.8	51	27.0	3	4.8	8	4.20
Oct. / Nov.	1992	19	30.2	50	26.5	4	6.4	6	3.20
April	1993	1	1.6	2	1.1				
June	1993	15	23.8	34	18.0			2	1.10
August	1993	8	12.7	16	8.5	2	3.2	4	2.10
November	1993	30	47.6	59	31.2	3	4.8	5	2.70
April	1994	1	1.6	3	1.6	1	1.6	1	0.53
June	1994	5	7.9	9	4.8	3	4.8	4	2.10
August	1994	12	19.1	21	11.1	2	3.2	5	2.70
October	1994	12	19.1	32	16.9	4	6.4	7	3.70

Tab. 3. Number of captured individuals (N) and relative abundance (RA) of *Apodemus sylvaticus* computed for the total material and for the first trapping day only (n1, ra1)

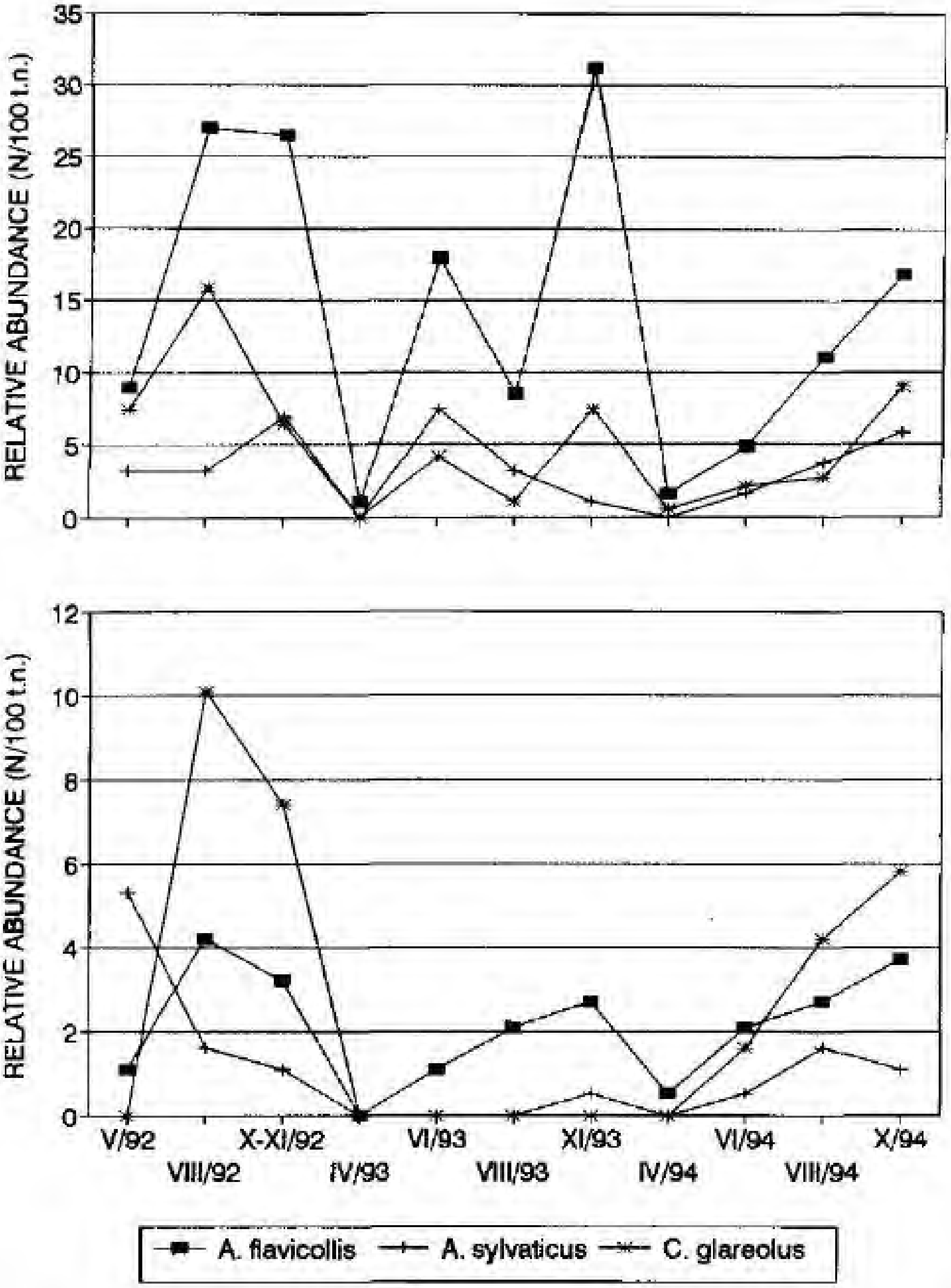
		Floodplain forest				Lime-hornbeam forest			
		n1	ra1	N	RA	n1	ra1	N	RA
May	1992	2	3.2	6	3.2	6	9.5	10	5.3
Augus	1992	2	3.2	6	3.2	1	1.6	3	1.6
Oct. / Nov.	1992	6	9.5	13	6.9	2	3.2	2	1.1
April	1993								
June	1993	10	15.9	14	7.4				
August	1993	4	6.4	6	3.2				
November	1993			2	1.1	1	1.6	1	0.53
April	1994								
June	1994	2	3.2	3	1.6			1	0.53
August	1994	3	4.8	7	3.7	1	1.6	3	1.6
October	1994	7	11.1	11	5.8			2	1.1

Tab. 4. Number of captured individuals (N) and relative abundance (RA) of *Clethrionomys glareolus* computed for the total material and for the first trapping day only (n1, ra1)

		Floodplain forest				Lime-hornbeam forest			
		n1	ra1	N	RA	n1	ra1	N	RA
May	1992	7	11.1	14	7.40				
August	1992	12	19.1	30	15.90	11	17.5	19	10.1
Oct. / Nov	1992	5	7.9	12	6.40	9	14.3	14	7.4
April	1993								
June	1993	2	3.2	8	4.20				
August	1993			2	1.10				
November	1993	5	7.9	14	7.40				
April	1994	1	1.6	1	0.53				
June	1994	3	4.8	4	2.10	2	3.2	3	1.6
August	1994	3	4.8	5	2.70	4	6.4	8	4.2
October	1994	8	12.7	17	9.00	7	11.1	11	5.8

sylvaticus and *C. glareolus* were euconstant species. *A. agrarius* and *P. subterraneus* were evaluated as accessory species in all 11 samples (Tab.1).

The mean value of relative abundance of the community was 22.9 individuals per 100 traps per night. The mean value of relative abundance, computed for the dominant species, was found 13.9 for *A. flavicollis*, *C. glareolus* 5.2, *A. sylvaticus* 3.3 individuals per 100 traps per night. The highest relative abundance was found for *A. flavicollis* in November 1993 (31.2 ind. per 100 t. n.), *C. glareolus* in August 1992 (15.9 ind. per 100 t. n.) and *A. sylvaticus* in June 1993



Figs 1 and 2. Fluctuation in the relative abundance of dominant species over the years 1992–1994. Fig. 1 (above). Fluctuation in the floodplain forest. Fig 2 (below) Fluctuation in the lime-hornbeam forest.

Tab. 5. Comparison of small mammal communities of different floodplain forest. Sources of data: 1 - Litovelské Pomoraví, N-Moravia, this study; 2 – near Vranovice, S-Moravia (Zejda 1973); 3 – near Lednice, S-Moravia (Zejda 1976); 4 – near Lednice, S-Moravia (Zejda 1991); 5 – Near Vranovice, S-Moravia (Zejda 1973); 6 – near Hodonín, S-Moravia (Zejda 1973); 7 – near Kroměříž, S-Moravia (Chytil 1981); 8 – Žitný ostrov, S-Slovakia (Májský 1985); 9 – near Vranovice, S-Moravia (Zejda 1973); 10 – Nové Mlýny reservoir, S-Moravia (Šebela 1980). Forest types: UFr – *Ulmeto–Fraxinetum*, UFrp – *Ulmeto–Fraxinetum populeum*, UFrc – *Ulmeto–Fraxinetum carpineum*, FrQ – *Fraxineto–Quercetum*, QFr – *Querceto–Fraxinetum*, * – after water regime measures. Methods: see text

Source	1	2	3	4	5	6	7	8	9	10
Forest type	UFrp	UFrp	UFrp, FrQ	UFrp, FrQ*	UFrc	UFrc*	UFrc	UFrc	QFr	QFr
Methods	LM/ST	LM/ST	QM/ ST+PT	QM/ ST+PT	LM/ST	LM/ST	QM/ ST+PT	LM/ST	LM/ST	QM/ ST+PT
T. europaea			0.06%							
S. araneus		2.2%	14.7	1.1%	4.4%	1.5%	8.2%	11.7%	2.3%	10.9%
S. minutus			1.3	0.6			2.2	1.5	0.05	2.2
N. fodiens			0.06				0.5			
N. anomalus							0.2			
C. leucodon								2.1		
A. flavicollis	60.7%	28.9	41.7	38.4	14.6	38	14.8	14.7	17	26
A. sylvaticus	14.3	6.2	0.13	25.6	2.3	7	4.8	2.9	1.6	
A. agrarius	0.8						0.2		0.05	
Apodemus sp.										9.8
M. minutus		0.4								
C. glareolus	22.5	62.3	33	31.9	76.4	51	65	46.1	75.4	48.9
M. arvalis			9	2.4	2.3	0.3	0.5	20	2.6	
P. subterraneus	1.7		0.06	0.1		1.2	3.6	0.7	1	2.2

(7.4 ind.per 100 t. n.). The lowest value was found in the spring months for all species. The decrease of the number of animals for all three species in August 1993 is interesting. Changes in the number of animals in each season are given in Figure 1 and Tables 2–4.

2. Lime-hornbeam forest

In this study area 5 species of small mammals were observed during the investigation: *S. araneus*, *S. minutus*, *A. flavicollis*, *A. sylvaticus* and *C. glareolus*. The mean value of the species diversity index was H'=0.94. The highest species diversity was found in late summer 1994 (H'=2.17). The mean value of equitability was E=0.51. The highest value was found in late summer 1994 (E=0.94). The minimal values of the indices of diversity and equitability were registered in 1993.

In the total sample material of 144 individuals, the highest value of dominance was made up by *C. glareolus* (38.2%), *A. flavicollis* (30.6%), *A. sylvaticus* (15.3%) and *S. araneus* (13.2%). These species were eudominant. *S. minutus* (2.8%) was a subdominant species. In the aspect of constancy, *A. flavicollis* was evaluated as a euconstant species, *A. sylvaticus* as a constant one. The three remaining species, *C. glareolus*, *S. araneus* and *S. minutus* were accessory (Tab. 1).

The mean value of relative abundance of the community was only 6.9 individuals per 100 traps per night. The three year average of relative abundance was the highest for *C. glareolus* with 2.7 individuals per 100 traps per night, while for *A. flavicollis* it was 2.1 and for *A. sylvaticus* 1.1 individuals per 100 traps per night. The highest values of relative abundance were recorded for *C. glareolus* (10.1 ind. per 100 t. n.) and for *A. flavicollis* (4.2 ind. per 100 t. n.) in August 1992 and for *A. sylvaticus* in May 1992 (5.3 ind. per 100 t. n.). The lowest value was found in the spring months for all species and for *C. glareolus* as well as for *A. sylvaticus* during the whole year of 1993. Changes in the numbers of animals in each season are given in Fig. 2 and Tab. 2–4.

DISCUSSION AND CONCLUSIONS

A comparison of the obtained results with other data from literature meets with range of difficulties caused by several reasons. Samples are obtained by different methods: (1) different type of traps: only pitfall traps (further abbreviated as PT, Aulak 1970), only snap-traps (further as ST, e. g. Májsky 1985, Čiháková et al. 1993), the use of combined catch in both mentioned traps (e. g. Šebela 1980, Zejda 1991), (2) different dislocation of traps, in lines (further as LM, e. g. Zejda 1973, Májsky 1985) or in the quadrats (further as QM, e. g. Pelikán 1974, Zejda 1976). Others differences are in the number of traps, in the time intervals of trapping, in combining material of different years, in the use of prebaiting etc.

Due to the small number of caught animals, the results may be distorted and overestimated. Nevertheless, it is possible to present at least several tentative comparisons here.

Most Czech authors use forestry nomenclature instead of fytocenology for the description of the vegetation in their works on community ecology of small mammals. A unification was made according to Randuška et al. (1986).

1. Floodplain forest

In this study area 7 species of small mammals were caught. Some values found in this locality are in some respect different from the results of other authors.

The dominance for *A. flavicollis* (60.7%) was higher (about three times) than for *C. glareolus* and this value is one of the highest values known in lowland forests. Conversely *C. glareolus* was less abundant (22.5%), which is even several times lower than determined by others authors (Tab. 5).

The occurrence and the dominance for *A. agrarius* (0.8%) in the floodplain forest are in accordance with the results by Chytil (1981, LM/ST+PT) and the relative abundance is not in contradiction with the data from Zejda (1967) for woods. Dudich & Štollmann (1983, LM/ST) even found a 41.3% dominance of this species. According to these authors, the occurrence of *A. agrarius* is caused by several factors (1) high population level of the species during research (2) fragmental pattern of the floodplain forests in the examined area, surrounded by agrocenoses providing alternation of the demotope, (3) a more or less stable water regime of the rivers and the exclusion of floods in the examined area.

Other differences from literary data are evidently the very low level of population density in *S. araneus* in the study area and the absence of *S. minutus* in the catches, as well as the high dominance of *A. sylvaticus*. These values are in accordance with the results of Zejda (1991, QM/ST+PT) for a floodplain forest in southern Moravia after water management measures. This author found increasing of densities of *A. flavicollis* and *C. glareolus*. The density of the whole community after changes in water regime also increased.

Neomys fodiens is also absent from the total catch Rumler (1988, PT) caught this species near my study area in a pitfall trap placed on a terrace of the same level as Morava river (3 ex) and in a pitfall trap placed in bank vegetation of a ditch (1 ex) This species might not have been caught during my investigations, because my traps were not exposed close to streams or because of extreme lack of water in periodically flooded ditches as well as in regular streams

The mean value of relative abundance of the community was 22 9 individuals per 100 traps per night, which is in the accordance with literary data A similar value found in an *Ulmeto–Fraxinetum* by Majsky (l c , 19 7 ind /100 t n), by Zejda (1973) in an *Ulmeto–Fraxinetum carpineum* (not flooded), 18 1 ind /100 t n) as well as by Dudich et Štollman (l c , 36 6 ind / 100 t n , after the elimination of the value of 15 ind /100 t n *A agrarius*)

2. Lime-hornbeam forest

In total 5 species of small mammals were caught in this locality This value is not in contradiction with literary data on 1st oak tiers

In the same forest type Pelikán et al (1974, QM/ST) as well as Zejda (1973, LM/ST) found *Microtus arvalis* (D=1% in *Tilio–Quercetum* and *Ligustro–Quercetum*) and *Pitymys subterraneus* (e g in *Tilio–Quercetum*)

Bobek (1971, 1973, QM/ST) found 8 species of small mammals in *Tilio–Carpinetum* including *Apodemus agrarius* 6 5%, *Pitymys subterraneus* 0 3%, *Microtus agrestis* 0 2%, *Muscardinus avellanarius* 0 2% and shrews (*S araneus, S minutus*) with a dominance of only 4 9% The Mole was not caught, but there were frequent proofs of the occurrence of this species within the site

The mean value of relative abundance of the community was only 6 9 individuals per 100 traps per night and are lower than the value found by Zejda (1973) in *Quercetum normale* as well as *Quercetum humile* (8 2 ind /100 t n), *Tilio–Quercetum* (13 6 ind /100 t n) and *Ligustro–Quercetum* (17 2 ind /100 t n) in oak tier

Acknowledgements

I would like to thank Vladimír Vohralík (Charles University, Prague, Czech Rep) for valuable comments and critical reading of the manuscript I further thank Jitka Spěšilová, Petr Benda, Vlastimil Rybka and Jan W Jongepier helping me with the preparation of this paper

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ISSN 0862-5247

Reproduction in *Apodemus sylvaticus* (Rodentia: Muridae) in captivity

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Received February 2, 1996; Accepted February 29, 1996
Published April 5, 1996

Abstract. Reproduction in wild-born *A. sylvaticus* and their descendants of the first, second or third generation born in laboratory was studied. The percentage of females that already had given birth increased gradually from less than one percent in the third month of life up to 87% at 12th month. The number of births per female and month increased slowly with female age, reached its peak (0.52) in the 12–13 months of life, and then decreased. Females produced litters throughout the year, but the intensity of reproduction was considerably higher during the spring–summer than in the autumn–winter periods. The litter size (n=208) varied within the range of 1–7 (most frequently 5), and significantly decreased with female age. The mean litter size revealed during the first week after parturition was 4.42 (n=102).

Litter size, breeding, sexual maturation, *Apodemus sylvaticus*

INTRODUCTION

The wood mouse, *Apodemus sylvaticus* (Linnaeus, 1758), belongs to the most widespread rodents in Europe. It seems to be the most generalistic species of the subgenus *Sylvaemus*.

Until now, a considerable research effort has been devoted to removal or capture-recapture studies describing the reproduction in wild populations of *A. sylvaticus* (e. g., Baker 1930, Straka 1965, Pelikán 1966, Saint-Girons 1966, Jüdes 1979, Frynta & Vohralík 1992, 1994). These studies described seasonality of reproduction and were focused mostly on geographic pattern of variation in reproductive parameters. Recently, most attention has been paid to analyses of population regulation in this species (Montgomery 1989a). It was suggested that in addition to food supply (Mallone & Flowerdew 1994) social interactions as, e. g., female spacing (Wilson et al. 1993b) and male infanticide (Wilson et al. 1993a) play an important role in density dependent regulation which affects the intensity of reproduction at the second half of the breeding season.

In contrast to numerous studies performed in the field, there is only a limited number of papers analysing the reproduction of *A. sylvaticus* in laboratory (e. g., Eriksson 1980, Clarke 1985). However, many aspects of *A. sylvaticus* reproduction remained unsolved and new data on breeding in captivity are still needed.

The aim of this study was to analyse: (1) sexual maturation, (2) intensity of reproduction in relation to season and female age, and (3) litter size variation. In addition, we compared reproduction of *A. sylvaticus* in captivity with that studied in the same region by removal sampling in the field (Frynta 1992, Frynta & Vohralík 1992, 1994). Sex ratio of progeny (Frynta & Žižková 1994) and postnatal growth (Žižková & Frynta 1992) in our laboratoty colony of *A. sylvaticus* were elaborated separately.

MATERIAL AND METHODS

Subjects

The laboratory colony of *Apodemus sylvaticus* was established from mice (45 males and 35 females) captured at several localities in Central Bohemia (mainly in Prague) during the autumn 1987. The mice under study were either wild-born animals or their descendants of the first, second or third generation born in our laboratory.

Housing conditions

Groups of captive animals, consisting of one or two pairs and their offsprings, were housed in glass terraria sized from 40×30×30 cm to 100×60×40 cm or in plastic cages 42×25×25 cm. The wild-born females were housed with males of the same origin. The laboratory-born females were paired with unrelated laboratory-born males of the same age. The cages were placed in a light controlled room in a long photoperiod (16L: 8D). The temperature varied seasonally within the range from 10 to 22°C (Fig. 2). Ad libitum water and food (DOS2B mouse and rat breeder diet) were provided. Each cage contained sawdust, nesting material (hay) and shelters.

Methods of data collection

The cages were controled daily (by searching for young or their vocalisation without opening shelters) and the presence of litters was recorded. The nests with new litters were inspected immediately when disclosed, but in litters found during the first three days after parturition the first inspection was usually delayed in order to prevent possible loses caused by early disturbance. During the inspection the number of young, their sex and weight were recorded. The birth date was estimated according to the weight and appearance of the young. The estimation was based on the growth curves and description of postnatal development in our colony that was given elsewhere (Žižková 1991). Number of young found in the nest was used as a measure of litter size. However, the complex environment in cages supplied with many shelters led frequently to late revelation of the litter. Therefore, the litters found and inspected during the first week of their life, are further referred as "newborns", while for those found later the denomination "juveniles" is used. Subsequent inspections of the nest were carried out weekly until weaning at the age of 4 or 5 weeks.

The growth and life history of all captive mice were thoroughly recorded. At weaning, all animals were individually marked by pelagging and/or toe-clipping (1 or 2 fingers). They were weighed monthly throughout their life-span. Therefore, the data on parity, body weight and age of each breeding female were available. It is necessary to point out, that the age was precisely known only for the laboratory born females. The wild-born females were captured as subadults in autumn. According to our knowledge of reproduction and age structure in wood mice populations, they were born most probably during the late summer period. Therefore, they were arbitrarily considered to be born in August. Age was expressed in months, i. e., the number of months of average length that had passed and/or begun was counted.

Male reproductive condition was checked monthly. The males with fully developed testes in scrotal position were considered to be sexualy active. This criterion was subjective, but due to the rapidity of maturation process, there was no doubt about the classification in most cases.

Tab. 1. Sexual maturation in laboratory-born *A. sylvaticus* males according to season of their birth. Spring = March–June, Summer–Winter = July–February

	spring			summer - winter		
Age [months]	n	sexually active	%	n	sexually active	%
1	166	0	0.0	139	0	0.0
2	152	73	48.0	102	34	33.3
3	136	110	80.9	76	48	63.2
4	113	103	91.2	53	43	81.1
5	92	91	98.9	45	34	75.6
6	73	72	98.6	41	39	95.1
7	43	42	97.7	36	36	100.0
8	27	26	96.3	33	33	100.0
9	26	26	100.0	23	23	100.0

RESULTS

Intensity of reproduction in laboratory-born mice

Maturation

The sexual maturation in the males born in spring months was slightly accelerated when compared with that in the males born during the rest of the year (Tab. 1). However, regardless of this fact, the majority of laboratory-born males matured during the second or third month of their lives.

In a sharp contrast to males, the first reproduction in the laboratory-born females was usually delayed for several months. The percentage of females that already had given birth increased gradually from one percent in the third months of life up to 87% at the twelfth month (Tab. 2). There were only two exceptional cases of the first reproduction prior to the fourth month of female age. These females (Nos. 197 and 423) gave birth at the age of 74 and 86 days (birth dates 13.06.1988, 15.05.1989), respectively.

Tab. 2. Sexual maturation in *A. sylvaticus* females born in captivity. Mature = females that already had given birth.

age [months]	n	mature	%	age [months]	n	mature	%
1	310	0	0.0	7	85	23	27.1
2	259	0	0.0	8	62	28	45.2
3	204	2	1.0	9	43	27	62.8
4	163	7	4.3	10	37	22	59.5
5	135	15	11.1	11	33	25	75.8
6	108	24	22.2	12	30	26	86.7

Age

The intensity of reproduction, expressed as the number of births per female and month, increased gradually with female age up to the peak value 0.52 in the 12–13 months of life. Then a drop to 0.19 in the last age category of 14–16 months followed (Fig. 1). Obviously, the intensity of reproduction in lower age classes was closely related to the number of females that had entered the reproduction up to the given age. Once entered the reproduction, females produced litters at higher rates (mean = 0.40 litters per female and month).

Seasonality

The laboratory-born *A. sylvaticus* females reproduced in our laboratory throughout the year. However, the intensity of reproduction was considerably higher in March – July than in October – January periods (Fig. 2). Nevertheless, low representation of females belonging to the to the upper age classes in the latter period should be mentioned (cf. Appendix 1).

Intensity of reproduction in wild-born mice

We analysed reproduction in 35 wild-born females housed with males of the same origin (Fig. 3, Appendix 2). At the time of capture in autumn 1987, mice of both sexes showed apparent signs of an autumnal block of sexual maturation, including testes regression in males. According to the size and scrotal position of testes, male sexual activity, started in January 1988. In females,

no signs of breeding had been recorded until March 1988, when the first two litters appeared. The period of intensive reproduction lasted from April to October. It was followed by the autumnal decrease of reproductive activity. In spite of its lower intensity, the reproduction continued throughout the winter till the end of the study in February 1989 when the animals were about 17–18 months old.

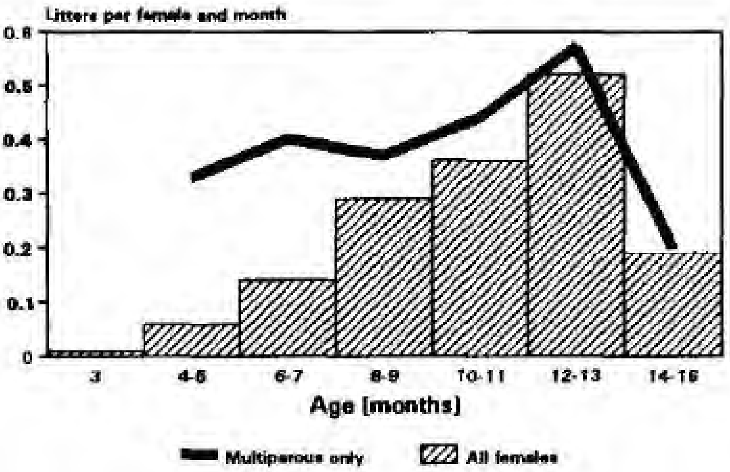

Fig. 1. Intensity of reproduction in relation to female age (in the laboratory-born females)
All females = values computed for all females and births (for sample sizes see Appendix 1) Multiparous only = only those females which previously gave at least one birth, and only second or successive litters were taken into account. Numbers of these females and their litters (starting from the age of 4–5 months) were 12(4), 37(15), 43(16), 41(18), 47(27), 40(8).

Litter size

Altogether, we examined 208 litters. The litter size varied within the range of 1–7. Litters consisting of five young were found most frequently. In 102 litters examined before the age of 7 days (further referred as newborns), the mean litter size was 4.42 (Tab. 3, Fig. 4). In remaining 106 litters which were recorded at higher age (juveniles), this value was slightly lower (4.06, $n=106$). The difference is a result of juvenile mortality that, therefore, was taken into account, when the mean litter size at birth was estimated. For this purpose, we used the relationship between the litter size and age, at which the young were counted. The extrapolation was done by a simple linear regression model. Resulting value 4.49 was very close to the above mentioned value 4.42 obtained from the litters recorded during the first week after birth. In addition, we dissected 11 pregnant females from our colony, the mean number of embryos in the set was 5.27. Further, we tested the hypothesis that litter size differs among individual females. We examined the subset of 38 females in which all the first three litters were recorded. Analysis of variance controlled for the effect of mortality (the age of young at the time of counting was taken as a covariate, $F=2.77$, $p=0.10$) revealed that neither Individual ($F=1.53$, $P=0.06$), nor Birth order (i. e., first, second, or third litter; $F=0.05$, $P=0.95$) contributed significantly to the variation in litter size.

Then, the entire set of available data on litter size (n=208) was further analysed by multifactor analysis of variance. As in the previous procedure, the age of youngs at the time of counting was given as a covariate ($F=5.46$, $P=0.02$) in order to control the effect of the within-litter mortality between the birth and the time of counting. The effects of the origin (wild-born vs laboratory-born females, F=2.76, P=0.098), female body weight (F=1.38, P=0.25), season (F=1.03,

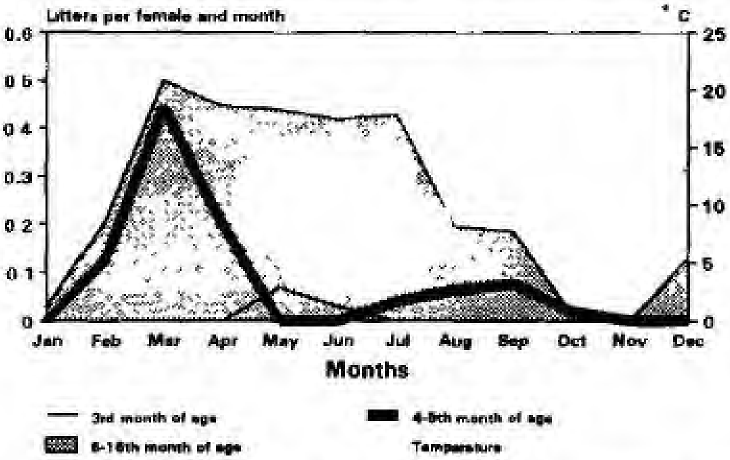

Fig 2 Variation in the intensity of reproduction during the year in the laboratory-born females Results for different age categories are given separately (for sample sizes see Appendix 1) Temperature = the ambient temperature in breeding room

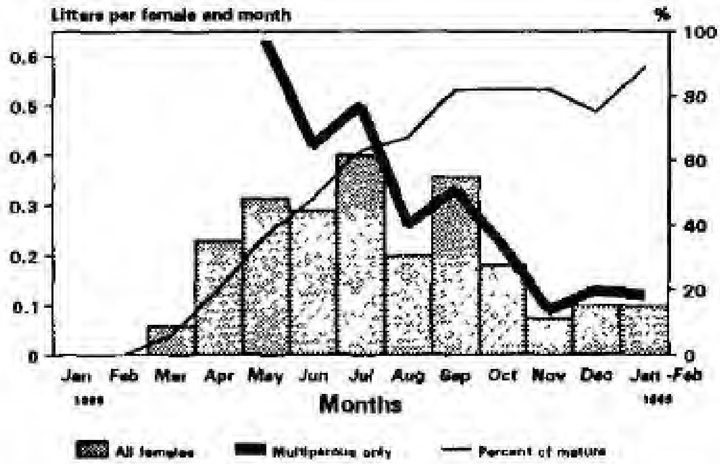

Fig 3 Intensity of reproduction in the wild-born *A sylvaticus* females from March 1988 to January – February period of 1989 Explanations All females (for sample sizes see Appendix 2) Multiparous (starting from March 1988) = only those females which previously gave at least one birth, and only second or successive litters were taken into account Numbers of these females and their litters were 0(0), 3(3), 8(5), 12(5), 16(8), 19(5), 21(7), 23(5), 22(2), 15(2), 6(1)

Tab. 3. Litter size in captive *A. sylvaticus* females. Explanations: Embryos = number of embryos found in dissected females, Newborns = number of young at the nest found during the first week of their life; Juveniles = number of young at the nest first recorded after 7th day of their life.

Sample	Litter size								n	mean	S.E.
	1	2	3	4	5	6	7	8			
Embryos	0	0	1	1	5	3	0	1	11	5.27	0.38
Newborns	3	7	16	17	40	15	4	0	102	4.42	0.14
Juveniles	5	13	15	28	31	11	3	0	106	4.06	0.14

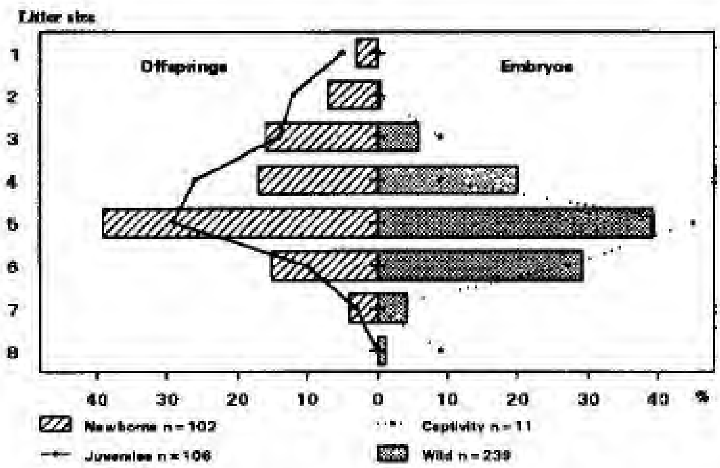

Fig. 4. Frequency distribution of litter size in captive *A. sylvaticus* and its comparison with that in wild populations of this species in Prague. Explanations: Newborns = number of young at the nest found during the first week of their life, Juveniles = number of young at the nest first recorded after 7 day of their life; Captivity = number of embryos found in dissected females born in captivity; Wild = number of embryos in the set in wild females captured in Prague (Frynta & Vohralík 1992)

P=0.36), and birth order (F=0.91, P=0.40) were not significant (Fig. 5). Female age (F=4.36, P=0.014) remained the only factor significantly contributing to the mean litter size. The young females (age category 3–8 months) produced in average significantly (Tukey: P<0.05) larger litters (4.46, S.E.=0.18, n=69) than the old females (age category 12–18 months: 3.91, S.E.=0.16, n=65), while the middle aged females (age category 9–11 months) showed the intermediate value (4.31, S.E.=0.16, n=74).

DISCUSSION

Maturation and relation between age and reproduction

Clarke (1985) found out that female *A. sylvaticus* "in laboratory condition which are entirely satisfactory for rapid sexual development of male wood mice develop sexually in a very capricious fashion". He found that the first pregnancies are difficult to iniciate, and this delay may take several months. In contrast, after the first pregnancy later ones follow very regularly. These

findings are strongly supported by our results, especially those concerning the laboratory-born females. However, more information about mating system and reproductive physiology in *A. sylvaticus* is needed to speculate about the causes of the phenomenon mentioned above.

There is a possibility to compare reproduction in our colony with that in wild *A. sylvaticus* in Prague (Frynta 1992, Frynta & Vohralík 1994). Unfortunately, in the material collected by snap-traps, no precise estimation of age is available and, therefore, the comparison is based on a weak relationship between the body weight and age as it was described elsewhere (Frynta & Žižková 1992). In spite of this limitation, it is obvious that the sexual maturation of the males in our colony was as rapid as in the spring-summer cohorts of the wild population (Frynta 1992). However, it is not the case of females. Although the minimal body weight of the youngest females entering the reproduction (14 grams) was the same both in the laboratory and the field, captive females usually gave their first birth at much higher age than those in the wild population.

Evaluating this phenomenon, we can look for stimuli possibly responsible for timing of the reproduction in the field (e. g, variation in light-dark cycle and food) that were absent in the laboratory. Nevertheless, females decision to start breeding at higher age can be evaluated also in the context of life-history theories. It is possible that there is a trade-off between the reproduction and survival in natural populations. Therefore, the delayed reproduction can be simply an adaptive response to suboptimal conditions, e. g., those in the laboratory. It is of interest in this context that unlike *Mus musculus* (Berry & Bronson 1992), females *A. sylvaticus* remained fertile throughout their adult life. It is obvious both from our results and from the fact reported by Clarke (1985) that some females in Oxford colony gave as many as 14 litters.

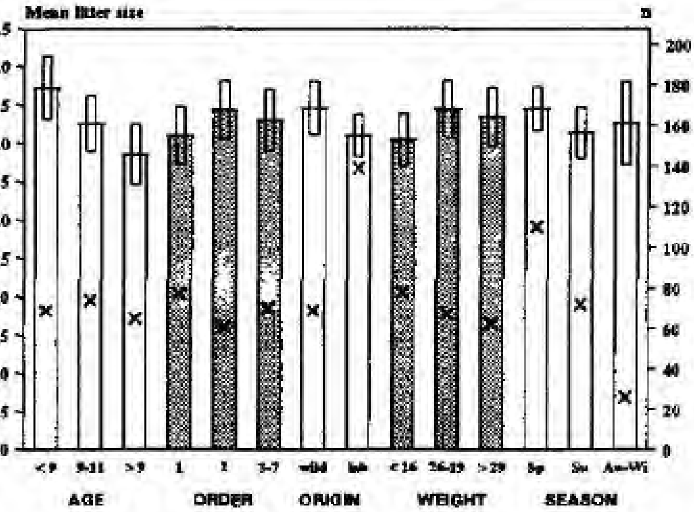

Fig. 5. The effects of female age, litter order, origin (wild vs. laboratory born female), female weight, and season on litter size in the total material of 208 litters as revealed by ANOVA model controled for mortality after birth, i. e., for age at which the counting of young was performed. Values represent mean litter sizes and their 95% confidence intervals. Sample sizes (the right ordinate) are indicated by crosses.

Intensity and seasonality of reproduction

There are two different modes of seasonal breeding in *A. sylvaticus*. While the breeding season in the populations inhabiting most of the distribution area in Europe lasted from spring to early autumn, the mediterranean populations reproduce throughout winter and their sexual activity decreases during hot summer months (Kowalski 1985, Moreno & Kufner 1988, Fons & Saint-Girons 1993). Obviously, at least in some populations, breeding is not confined to the long photoperiod and the action of additional reproduction regulating stimuli could expected. It is in accordance with our results. Although we kept the animals in a constant photoperiod, there was a seasonal variation in reproductive intensity resembling that one in wild populations. The ambient temperature is often believed to be another important factor regulating the reproduction in *A. sylvaticus* (Clarke 1985). In spite of this, the period of intensive reproduction in our laboratory was apparently not directly associated with the annual cycle of temperature in the breeding room (Fig. 2), e. g., the intensity of reproduction increased when the ambient temperature was the lowest (February – March). However, despite the seasonal variation in the intensity of reproducion was obvious, the period of deep reproductive inactivity comparable to that reported in wild populations was not found. Some breeding events were recorded even in December and January. It should be mentioned here that male testes remained in scrotal position throughout the winter.

The wild-born *A. sylvaticus* were captured in autumn, and therefore they were the only animals in our laboratory that were affected by the autumnal block of sexual activity regularly occurred in nature. The spring onset of their reproduction seems to be synchronous with that in the wild population in Prague. The first births in our laboratory recorded in March correspond well with the fact that in Prague, the first pregnant female was captured in February, and in March the percentage of pregnant females reached 13% (Frynta & Vohralík 1994).

The values of the average number of litters per female and month recorded in our laboratory were in most cases considerably smaller than those in wild population (cf. Frynta & Vohralík 1994). This difference can be attributted either to the artificial conditions in the laboratory or to a possible over sight of the litters which disappeared shortly after birth.

Litter size

The mean number of newborns per litter found in our material (4.42) resembles the value 4.23 (S.E.=0.10, n=100) reported by Eriksson (1980) from a laboratory colony in Lund (Sweden), while the corresponding value from the Oxford colony reported by Clarke (1985) is significantly higher (5.0, S.E.=0.1, n=372). Having no paralel in geographic variation of litter size in natural populations (cf. Frynta & Vohralík 1992), these differences should be atributted to the breeding conditions.

The mean number of embryos in our material from laboratory (5.27) corresponds well with 5.08 (n=239) reported by Frynta & Vohralík (1992) in the wild population of *A. sylvaticus* in Prague. Thus, there is an agreement between our findings and results reported by the authors mentioned above (Eriksson l. c., Clarke l. c.) that the mean number of newborns per litter is considerably smaller than the mean number of embryos per set obtained in the same population. Most probably, this disparity could be due to a loss of young immediately after birth as a result of mortality and/or possible infanticide. Although foetal resorption decreases the litter size in some rodents considerably (Loeb & Schwab 1987), rates of embryonic resorption reported in most populations of *A. sylvaticus* (Frynta & Vohralík 1992) are too small to produce disparity of a comparable size.

Litter size variation was extensively studied in North American species of the genus *Peromyscus*, which is apparently an ecological equivalent of *Apodemus* (Montgomery 1989b). There is

a strong pressure to optimalisation of the litter size in *Peromyscus*. It is due to relationships between this variable and several correlates of fitness as, e. g., young weight, growth and fertility (Leamy 1981, Millar 1983, Myers & Master 1983). The litter size in laboratory *Peromyscus maniculatus* considerably increased with female weight and parity, however, the effect of the latter factor was attributable to the former one. When the effects of the above factors were subtracted, the female age remained to be important in determining the litter size. With the exception of the youngest females (50–100 days of age) it gradually decreased with the female age (Myers & Master 1983).

Only limited data about relationships between the litter size and female weight, parity and age are available in *A. sylvaticus*. The litter size in the wild population of this species in Prague was positively, bu not significantly associated with the female weight (Frynta & Vohralík 1992). Clarke (1985) demonstrated in the Oxford laboratory colony of *A. sylvaticus* that the first two litters were in average smaller than the subsequent ones. However, we found no significant effect of parity on the litter size. On the other hand, we found a significant decrease of the litter size with female age in our colony of *A. sylvaticus*.

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APPENDIX 1.
Numbers of the laboratory-born *A. sylvaticus* females and their litters (given in parentheses) present in our breeding colony according to month and female age (in months).

Age	Months											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	11(0)	3(0)	18(0)	44(0)	41(0)	42(0)	51(0)	27(0)	34(0)	29(0)	6(0)	4(0)
2	4(0)	7(0)	2(0)	18(0)	39(0)	38(0)	40(0)	49(0)	16(0)	32(0)	8(0)	6(0)
3	5(0)	4(0)	7(0)	2(0)	15(1)	38(1)	34(0)	34(0)	33(0)	15(0)	13(0)	4(0)
4	3(0)	5(0)	4(4)	6(0)	1(0)	15(0)	35(1)	31(2)	18(0)	30(0)	9(0)	6(0)
5	4(0)	3(1)	5(0)	4(2)	6(0)	1(0)	14(1)	32(2)	21(3)	18(1)	20(0)	7(0)
6	7(0)	4(0)	3(2)	5(1)	4(3)	2(0)	0	12(4)	26(5)	20(1)	9(0)	16(2)
7	14(0)	3(0)	4(1)	3(1)	5(1)	4(1)	2(0)	0	11(3)	24(0)	7(0)	8(2)
8	8(0)	14(3)	3(3)	3(1)	3(0)	5(3)	4(2)	2(0)	0	11(0)	2(0)	7(0)
9	6(1)	7(2)	12(6)	3(3)	3(2)	3(0)	5(4)	4(0)	0	0	0	0
10	0	6(2)	6(0)	12(3)	3(1)	3(1)	2(0)	5(0)	0	0	0	0
11	0	0	6(5)	6(3)	11(7)	3(2)	3(0)	2(1)	2(0)	0	0	0
12	0	0	0	6(5)	6(1)	11(7)	3(1)	3(0)	1(0)	0	0	0
13	0	0	0	0	6(3)	6(2)	11(8)	2(2)	0	1(0)	0	0
14	0	0	0	0	0	6(2)	6(2)	10(2)	1(0)	0	0	0
15	0	0	0	0	0	0	6(1)	6(1)	2(0)	1(0)	0	0
16	0	0	0	0	0	0	0	5(0)	0	0	0	0

APPENDIX 2.
Numbers of the wild-born *A. sylvaticus* females and their litters (given in parentheses) present in our breeding colony from the beginning of their reproduction in March 1988 to February 1989. Females = number of females which survived up to given month; Mature = females which gave at least one litter; % = the percent of Mature among Females; Births = the number of litters recorded in the given month;

Month	Female	Mature	%	Births	Month	Female	Mature	%	Births
March	35	2	6	2	September	28	23	82	10
April	35	7	20	8	October	28	23	82	5
May	35	13	37	11	November	27	22	82	2
June	31	15	48	9	December	20	15	75	2
July	30	19	63	12	January	18	15	83	0
August	30	20	67	6	February	2	2	–	2

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Podávání novinových zásilek povoleno Ředitelstvím pošt v Praze č j NP 1176/1994 ze dne 13 6 1994